NEW ZEALAND GEOGRAPHER

7 No. 1
IL, 1951

N.Z. GEOGRAPHICAL SOCIETY (INC.)

THE NEW ZEALAND GEOGRAPHICAL SOCIETY

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The Society is not responsible for the opinions or statements of writers in this Journal.

Published half-yearly at the press of
WHITCOMBE AND TOMBS LTD., CHRISTCHURCH, NEW ZEALAND
by the New Zealand Geographical Society (Incorporated)

EDITORIAL OFFICE: Auckland University College, Auckland, New Zealand

MEMBERSHIP OF THE SOCIETY is to be obtained through the constituent Branches: Annual dues *one pound.* Members are entitled to receive one copy of all regular publications of the Society.

SUBSCRIPTIONS TO THE JOURNAL are accepted from libraries and other organisations n New Zealand at the annual rate of *one pound,* and from both libraries and individuals overseas t the rate of *one pound* in the currency of the country to which the journal is to be addressed. (*Four dollars* in the United States and Canada.)

Registered at the G.P.O. Wellington as a magazine.

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New Zealand Geographer

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PASTORAL MURIHIKU

HOWARD J. CRITCHFIELD

THE MAORI NAME for Southland was Murihiku—'the last joint of the tail'. Presumably because of its position at the southern extremity of New Zealand, Southland is very often omitted from the itineraries of visitors to the dominion, scientists as well as tourists. Yet here is one of the most distinctive and most diverse regions of New Zealand. It has unity because of the sharp economic focus on Invercargill and the port of Bluff, and it has distinctiveness, primarily by virtue of its climate, but also because of its highly developed pastoral production. Diversity within the region arises from physical differences, especially terrain, and is emphasised by such extremes as the intensive pastoralism of the alluvial Southland Plain and the unexplored interior of the rugged Fiordland Plateau.

While for most New Zealanders and for practically all foreigners the term Southland may need some clarification, it is generally conceded to refer approximately to the hinterland of Invercargill. The Land District boundary is used here to define Southland areally, and includes the counties of Southland, Wallace and Fiord, Stewart Island, and portions of Lake and Clutha Counties, as well as several outlying islands not part of any county. Of the total area of nearly 13,000 square miles only about 5000 square miles are occupied. The Fiordland tectonic block, a deeply dissected plateau clothed in a luxuriant rainforest, is virtually unpopulated. Stewart Island has proved almost as formidable to settlers. It is rugged and uninviting to agriculture, with the exception of a grassy plain along Mason Bay on the west and a swampy basin in the graben occupied by the Freshwater River.

By far the most important landform area of Southland is the Southland Plain. It is built up of greywacke shingle and silts on the coalescing floodplains of the Aparima, Oreti and Mataura Rivers. By virtue of its gentle slope and accessibility it constitutes the chief agricultural region of the land district. Around this plain lies a chain of discontinuous highlands, the Longwoods and Takitimus in the west, the Taringatura Hills and Hokonui Hills on the north, and the Forest Range and associated hill country in the east. Outside these uplands lies a series of terraced gravel plains, the Waiau, Mararoa, Five Rivers and Waimea Plains. The whole is blocked off by higher mountain ranges on the west and north (*Fig.* 1).

THE CONTROVERSIAL CLIMATE

The climate of agricultural Southland has been classified by Garnier, using the method of Thornthwaite, as humid microthermal with adequate rain in all months (BC′r).[1] This applies to the Southland Plain and the outlying gravel plains. A similar climate is found in Hokkaido, Wales or northeastern United States. Considerable newspaper space has been used in condemnation and defence of the climate of Southland, undoubtedly more than for any other district of New Zealand. Even Wellingtonians have decried the gales of Foveaux Strait. This is, of course, a clear case of the pot calling the kettle black, for Cook and Foveaux Straits earn equal honours in numbers of gales per year.[2] In the matter of sunshine hours, however, coastal Southland stands convicted. That the allegations of cloudiness, rainy days and cold winds are true is evident from personal experience as well as from reference to climatic records. But if the relative severity of its climate sets Southland apart from the rest of New Zealand the direct results of that climate are even more effective in establishing a regional character. The longer winter has made necessary the provision of more supplementary feed for livestock than in more northerly areas. The high precipitation effectiveness throughout the summer maintains fresh green pastures and a consequent high carrying capacity. When Canterbury and North Otago grasslands dry up in late summer the sown pastures of 'rainy Southland' provide welcome feed for sheep brought in from those districts. Southland has an excellent climate for intensive pastoral production, and concrete proof of this is found in the substantial exports of frozen meat, wool and cheese.

Prejudiced by the obvious prosperity of the rural landscape, farmers and scientific writers alike insist on referring to the soils of Southland

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[1] B. J. Garnier: 'The Climates of New Zealand according to Thornthwaite's System of Classification', *Annals Assoc. Amer. Geogrs.*, Vol. 36, No. 3, 1946, pp. 151-177.

[2] I. E. M. Watts: 'The Relation of New Zealand Weather and Climate', *N.Z. Geographer*, Vol. 3, No. 2, p. 126.

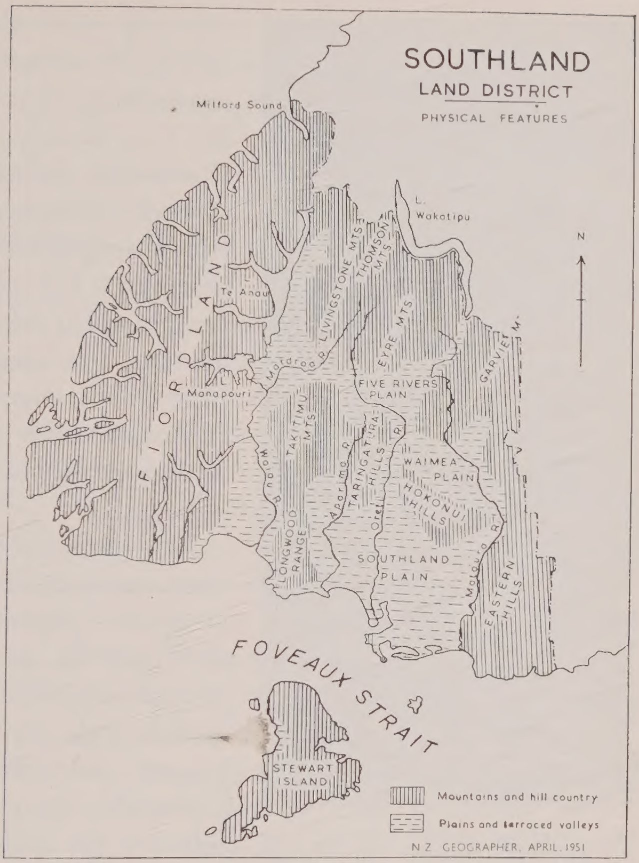

Fig. 1. Southland: Surface Configuration. For scale see *Fig.* 5.

as naturally fertile, and in the same breath they utter the half-truth: 'Lime has made Southland'. These statements are not compatible. Southland's soils are not naturally fertile. They are generally acidic and lack calcium, phosphates and nitrogen as well as sufficient amounts of the trace elements, notably cobalt. Cobalt deficiency in soil as reflected in animal health was known as Morton Mains disease because of its early recognition in the vicinity of Morton Mains, northeast of Invercargill. Yet today the land around Morton Mains produces some of New Zealand's best fat lambs. This is the result of induced fertility. Nor have crushed limestone, superphosphate and trace elements alone been responsible for increasing the production from Southland's soils. Very nearly all of the Southland Plain requires artificial mole, tile and ditch drainage. Land drainage is one of the most urgent requirements for improving farmlands and adding to the productive area of the accessible flat lands. The poor natural drainage of the river plains may be ascribed to their lack of gradient

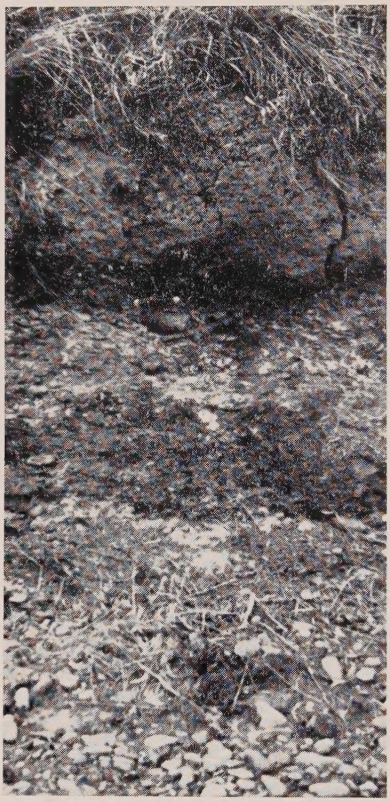

Fig. 2. Ironstone Pan Profile on the Dipton Flat. The layer of cemented shingle through the middle of the profile is sixteen inches thick.

and to the resultant claypan formations in the subsoil. Such impervious horizons occur even in some of the very shingly terraces which would at first glance appear to have excessive drainage. The extreme case of hardpan formation is on the Oreti River floodplain in the vicinity of Dipton where a cemented ironstone pan underlies scattered areas on the Dipton Flat (*Fig.* 2). Blasting is often necessary when ditches are dug in these ironstone soils.

Whether it be on low-lying alluvium, on immature podsols of the previously-forested areas, or on tussock land, the annual applications of a ton or more of lime per acre have brought a response in grass growth, and ultimately in meat production. For most farms this is still true, but in recent years difficulties in fattening lambs on some apparently healthy paddocks have caused increasing concern. On the Southland Plain liming has been such a universal practice that many of the older grass farms have now reached the stage where grass growth (and consequent carrying capacity) can no longer be increased by lime and phosphate alone. The putting of calcium into soil is a vital, necessary and intelligent thing to do in most of Southland. The constant use of crushed limestone adds calcium to the soil but at the same time tends to produce alkalinity as it reduces acidity. Excessive liming can also upset the balance of available minerals in the soil, and this may be a danger in Southland.

The complicated problem of maintaining balanced soil fertility under the edaphic, climatic and land-use conditions of Southland requires detailed study. There appears to be little doubt that the present practices of fertiliser application will need revision if production levels are to be maintained or increased on old farmlands. Whatever remains to be learned about the proper proportions of essential minerals, it is evident that in Southland's soils they do not occur *naturally* in amounts conducive to maximum production.

The People and the Province

It has been suggested that Southland's climate has operated selectively by driving all weaklings to more northerly districts. It would be difficult to prove such a statement, but it is true that Southland's inhabitants are generally prosperous and deserve their prosperity. There is a minimum of poor farmers, and the urban settlements reflect the prosperity of their tributary areas. Perhaps some form of selection, climatic or otherwise, has also eliminated all but the parochial in outlook, for among the dominion's people none are more ardent protagonists of their own province than Southlanders. Pride in one's homeland is a good thing if it does not degenerate into smug complacency. Obviously in Southland civic pride is still aiming in the direction of progress.

A large share of Southland's population is of Scottish descent, the proportion in Southland being greater than in any other land district. Most of the early settlers came from elsewhere in New Zealand, especially from Otago, though a few immigrated from Scotland. By a quirk of history Murihiku was not settled under the Wakefield scheme but was rejected as a site for a 'New Edinburgh' by Frederick Tuckett, who inspected the district in May 1844 and wrote in his diary:

> I regretted that I could not form here the settlement, where there are so many facilities and beauties to recommend it for selection; but my duty was clear to me. I had seen far better land with a better climate; the frequent recurrence of rain here at all seasons of the year reduces the number of working days equal to 25 per cent on the cost of labour compared with some other districts.[3]

Soon after Otago was established, however, pastoralists pushed into Murihiku in search of suitable sheep runs. Sectional feeling developed at this early date over taxes, land laws and public works, and in 1861 the Southland Province was created separate from Otago. The province extended between the Waiau and Mataura Rivers. Stewart Island was added in 1863. During the short and erratic life of the province an attempt was made to draw settlers from Great

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[3] T. M. Hocken: *Contributions to the Early History of New Zealand: Settlement of Otago*, London, 1898. Appendix A: Mr. Tuckett's Diary, p. 224.

Britain, but there was no organised scheme as in other parts of the colony. In a pamphlet issued in 1866 in Invercargill for distribution to prospective immigrants proud comparisons with other New Zealand provinces were made. Several advantages were claimed for the most southern province, among which were freedom from Maori troubles, large areas of accessible land, available timber, simple land settlement laws and a climate similar to that of England.

Yet in spite of earnest intentions Southland as a province failed financially, and therefore politically. In 1870 it was reunited with Otago and so remained until 1875 when provincial government was abolished. But the conception of Southland as a more or less distinctive unit has always persisted for Southlanders as well as for most other New Zealanders. Partly because of their continued parochialism, and probably more because of their unbounded hospitality, the people contribute nearly as much to the regional character of Southland as any physical factor. Perhaps the most deserved compliment paid to them is that 'their climate is cold but their hearts are warm'.

URBAN SOUTHLAND

With rare exceptions Southland's urban settlements function directly as trade and service centres for the main industry, agriculture. Ohai and Nightcaps are primarily mining towns serving the coal-mining area in which they are situated. Half Moon Bay on Stewart Island is essentially a fishing village with tourism contributing heavily towards support of the population. Some other settlements such as Tokanui, Haldane and Niagara depend on timber milling for their existence but they are in the area east of the Mataura where farming is gradually replacing the native bush.

Invercargill is the regional capital and economic focus of Southland. This city of 30,000 people affords a distinct contrast with most other New Zealand towns and cities. Its street pattern and reserves are a monument to the surveyor of the site, John Turnbull Thomson, who also surveyed Singapore. The wide business streets are frequently the butt of jokes, but it is a fact that Invercargill is the best-planned city of New Zealand. Its flat site gives a distinct advantage which Thomson did not nullify. But this same flatness and orderly layout detracts from the hustle and bustle normally expected in a city of 30,000. Invercargill is not industrial; it is a trade centre for an agricultural hinterland. Bluff, seventeen miles to the south, is the port

Figs. 3 and 4. Southland Landscapes. Mataura and the eastern hill country; oats and sheep at Otautau where the Southland Plain borders the Longwood Range.

and its harbour is the only excuse for its existence. Besides handling the imports and exports of Southland, it is a base for fishing and oyster dredging.

Gore, with nearly 6000 people, is the trade centre for northeastern Southland. By virtue of its location at the eastern end of the Hokonui Hills, it commands the eastern Waimea Plain, as well as a part of the Southland Plain. Mataura, seven miles to the south, has a freezing works, a paper mill and a dairy factory (*Fig.* 3). Further down the Mataura River, Wyndham and Edendale are dairying centres. Several other towns serve their local areas but nevertheless look to Invercargill. Winton, Otautau, Riverton, Lumsden and Tuatapere are examples. The last is of especial interest because it is on the frontier where agriculture is pushing west of the Waiau into the beech forests (*Fig.* 6).

PASTORAL SOUTHLAND—DAIRYING

Southland is the leading dairy region of the South Island and has one of the longest histories of dairy production in New Zealand. The first permanent cheese factory in New Zealand was established at Edendale in 1881 after dairying in the vicinity had been proved economic by the New Zealand and Australian Land Company. The pioneering work was led by Thomas Brydone, and butter making soon followed. Philpott states that the *Dunedin,* which carried the first cargo of frozen meat to England, also carried some butter 'probably made at the Edendale Dairy Factory'.[4] Later at Edendale New Zealand's first sugar-of-milk factory was built to convert whey into a valuable byproduct. Today Southland has forty cheese factories, one butter factory, a milk condensory and the sugar-of-milk factory.

The most striking feature of Southland's pastoral production is the apparent overadjustment to a relatively long winter. This is exemplified especially in dairying. The forty cheese factories close every winter for lack of milk supplies. This concentration on summer production seems on the face of it to be a logical system for utilising pastures with a minimum of human effort; and it most certainly contrasts with the labour-demanding stall-feeding methods of north-western Europe and North America. Such a system is possible with cheese destined for a distant northern hemisphere market, but does not represent the most economic use of land, even though the dairyman gains some freedom from domination by the cow. From the point of view of maximum production, the dairy cows of Southland are starved in spring and autumn when they ought to have supplementary feed, and until the labour problem is solved, efficient production per unit of land will not be attained. Breeding of high-producing dairy animals and the maintenance of output all the year round by means of supplementary feed can together greatly increase the dairy exports of Southland without an augmentation in the total number of dairy cows.

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[4] H. C. Philpott: *A History of the New Zealand Dairy Industry, 1840–1935,* Wellington, 1937, p. 37.

Another contrast with northern hemisphere continental dairy regions is the absence of barns. A characteristic feature of the American farmstead is a large barn used to house livestock and hay. The milder climate of Southland obviates the absolute necessity for this type of shelter for dairy cows. It is doubtful whether the maximum production can be achieved without winter shelter and certainly there is a strong case for housing hay and ensilage.

Fat Lambs and Mutton

Still another feature of dairying in Southland is the universal combination with fat-lamb rearing. This is largely a result of ragwort. Almost every dairy farmer keeps a flock of ewes which control ragwort and provide a fat-lamb crop each year. Thus even on farms where milk is the main source of income fat lambs are also produced. This combination has made it comparatively easy for dairymen to switch over to fat lambs, and high meat and wool prices have encouraged a strong trend in this direction. Whereas cheese exports have shown a slight decrease over the past two decades exports of wool have quadrupled and those of frozen meat have nearly tripled.

Southland has nearly three and a half million sheep, the majority of which contribute directly or indirectly to the production of meat.

Soon after the advent of refrigeration in the 1880's the emphasis of the sheep industry shifted from wool and tallow to frozen meat. Sheep rearing today is aimed towards meat export. The latter has received a strong impetus from increased demands in the United Kingdom during the past decade.

In the production of fat lambs and mutton for freezing, the drier tussock grasslands of the hill country and the more productive lowlands are complementary. The function of the hill-country farmer is to provide an annual draft of breeding ewes which are sold to intensive grassland farmers and used to produce fat lambs. Wether lambs and wether hoggets are similarly disposed of for fattening and subsequent slaughter. Fat lambs dominate meat production, and the general high standard of quality and the number of carcasses exported (1,895,084 lambs in 1949) would seem to justify a certain pride in this important commodity. It is difficult, therefore, to understand why Southland lambs are still shipped to England marked 'Super Canterbury Lamb'. Such a brand appeals to a buying tradition among British housewives, but today, when the demand for meat obviates the need for advertising psychology, the opportunity should be seized to correct this error.

Winter Feed Problems

The seasonal nature of fat-lamb production is quite marked. Winter feed must be provided for ewes and dry sheep and this presents one of the greatest problems to the sheep farmer.[5] The common winter feeds are brassicas, which require a minimum of labour in feeding. However, turnips are often fed most heavily in the critical spring period just prior to lambing and the beginning of grass growth. They are at their lowest level of food value at this time and the turnip paddock is usually a mass of mud which adds to the undesirability of the feed. Losses among the ewes result. More hay and special-purpose early-growing pastures are needed to overcome this situation.

As with dairying the seasonal availability of sufficient grass and fodder crops for sheep is accompanied by seasonal activity in the secondary industry. The three freezing works in Southland, located at Ocean Beach (Bluff), Makarewa and Mataura, open in the first or second week of January and continue killing and freezing operations until early June. If summer grass growth is good, farmers may hold their lambs a few extra weeks to convert as much herbage as possible, so that by February a temporary congestion may develop at the freezing works. The Mataura works has a killing and freezing capacity of 6000 lambs per day whilst Ocean Beach and Makarewa have a daily capacity of 10,000 lambs each. A proportion of the fat lambs goes to the Burnside works near Dunedin, and buyers for freezing works in Canterbury come into Southland for lambs after the peak of Canterbury's killing season is passed.

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[5] See G. A. Thomson and W. L. Harbord: 'Winter Feeding of Stock in Southland', *N.Z. Journ. of Agric.*, Vol. 76, 1948, pp. 421-424.

Wool and Beef

Nearly three million sheep shorn annually contribute the bulk of Southland's wool output. To this is added the slipe wool removed from pelts at the freezing works. Although wool is the leading export from the region very few farmers keep sheep primarily for wool production. Wool is essentially a valuable byproduct of lamb and mutton production. The position of wool in the exports through Bluff is shown in Table I.

TABLE I

Value of Exports through Bluff (*in £N.Z.*)

	1945	1946	1947	1948	1949*
Wool	958,790	1,904,032	2,734,502	3,670,992	4,363,382
Frozen Meat	2,077,098	2,798,668	3,446,263	3,285,723	2,924,417
Cheese	1,235,019	857,598	972,221	1,359,633	1,189,916

*January to September.

In the early days of the sheep industry in the South Island, merino breeding stock was imported from Australia as a basis for fine-wool producing flocks but never did well in Southland's wet conditions. British breeds proved better suited to the climate. The Romney ewe proved to be a good fat-lamb producer when mated with a Southdown ram, and at the same time, Romney and Romney cross-bred wool was in reasonably good demand. Although nearly all of Southland's wool clip is exported, a small amount is used by a woollen cloth factory at Rosedale near Invercargill.

Like dairying, beef production has gradually been giving way to fat-lamb production over the past few years. In 1947 dairy stock totalled 75,661 animals whereas beef animals numbered only 70,785.

Rearing of beef cattle has never been popular among Southland farmers chiefly because of the delayed financial return as compared with sheep. Sheep rearing brings an annual income from wool as well as from store sheep or fat lambs and mutton, but considerable capital outlay is required both for animals and fencing to establish beef production and to develop it to an economic level. Beef cattle remain as a sideline for most farmers since they are useful in controlling rank and coarse grasses. Hereford, Shorthorn and Aberdeen Angus breeds predominate, but purity of breed is not general.

Another factor militating against beef is that it loses its quality when frozen and thus cannot in normal times successfully compete with chilled Argentine beef on the British market.[6] Under the most favourable conditions of storage and shipping, chilled beef will maintain its quality for not more than six weeks, and Bluff is five weeks from the United Kingdom by the most modern cargo ship. Thus the export of chilled beef requires a dependable supply of beef animals and an efficient organisation for rapid preparation and shipment. Southland has neither of these prerequisites so that freezing is the alternative.[7] Export of frozen beef reached its peak during the second World War but has fallen off again in postwar years. In the 1949 season 7731 cattle were killed for export through Bluff.

CROPS

The combination of crops and livestock in a farm economy has been classified by Whittlesey under 'Commercial Livestock and Crop Farming; often called "mixed farming" '.[8] If Whittlesey's definition be accepted then virtually every farmer in Southland has a mixed farm whether he be primarily a fat-lamb farmer, a dairyman or a grass-seed producer. The number of animals on a farm is largely determined by the amount of pasture and supplementaty feed which is available through the winter months. Accordingly a portion of the farm area must be set aside for growing some form of fodder. But the problem of supplementary feeding is not the sole basis of cropping. The cultivation of turnips or swedes, for example, improves soil tilth and results in better yields from succeeding grain crops or grass.

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[6] R. O. Buchanan: *The Pastoral Industries of New Zealand,* London, 1935, p. 36.

[7] An experimental shipment of chilled beef from Bluff to London in 1939 arrived in a satisfactory condition but was a financial loss.

[8] D. Whittlesey: 'Major Agricultural Regions of the Earth,' *Annals. Assoc. Amer. Geogrs.,* Vol. 26, 1936, p. 231.

Considered from the point of view of cash income to the farmer, field crops rank low in comparison with animals in Southland, but as a basis for pastoral production they are almost as important as grass. Fodder crops are essential for bridging the gap which winter makes in pasture growth and they account for nearly three-quarters of the crop area of the Land District. The relatively greater dependence of Southland on fodder crops can be seen in Table II.

Southland was noted for oat production in the early years of this century. The decline in the use of horses for farm power was accompanied by a decline in oat acreage, but Southland still grows a fourth of New Zealand's oats for threshing, most of it on the Southland and Waimea Plains (*Fig.* 4).

TABLE II

NUMBER OF LIVESTOCK AND ACREAGES OF PRINCIPAL FODDER CROPS, 1946–1947 SEASON

Sheep	10.35	Swedes	32.47
Dairy cows	2.93	Yellow turnips	30.24
Beef cattle	3.46	White turnips	11.53
Pigs	1.05	Turnips and rape	52.13
Horses	7.63	Oats for green feed	19.83
		Grass and clover hay	5.57
		Ensilage	0.05

Figures represent percentages of dominion totals.

Wheat has never occupied a large area of Southland's cropland and the acreage within the Land District in recent years has been less than five percent of the dominion total. Yields are high, however. The world's record wheat yield is claimed for a farm in the vicinity of Drummond, northwest of Invercargill, where in 1939 a yield of 112 bushels per acre was harvested from a field of seven and a half acres.

Production of grass and legume seed is a natural adjunct to intensive grassland farming and consequently Southland has met its domestic requirements for most seeds and developed a remunerative export trade. However, grass and clover seeds are for the most part a by-product of pastoralism; they are a good source of cash which can be obtained where there is a surplus of pasture growth. There are very few seed farmers. The principal seeds produced are Chewing's fescue, browntop, cocksfoot, dogstail and timothy. Because of the generally damp harvesting conditions, ryegrass is particularly susceptible to the blind seed disease in Southland and it is therefore not harvested in very great quantities.

The outstanding characteristic of Southland's cropping system is its almost complete domination by introduced crop plants. There is but one exception, *Phormium tenax*. Phormium fibre was one of the first products to be exported from Southland and was responsible for some of the early exploration there. Fibre production today still depends largely on the natural growth of the plant. There is, however, a plantation of about one thousand acres in the Redan valley south-east of Wyndham and there are several areas of phormium swamp which have been improved by drainage. There are five phormium stripping mills in Southland for processing the green leaves. Production of linen flax in the vicinity of Winton supports a linen-flax factory southwest of the town but the crop is essentially a carryover from the artificial stimulation of wartime demand.

RABBITS

Along with the many plants and animals which the settlers brought to Southland from Britain came most of the pests which attack these plants and animals.[9] In some cases, such as the importation of rabbits, gorse or sweet vernal, the introduction was deliberate, but many weeds and diseases came accidentally through carelessness or ignorance of their potential danger. Unfortunately ecological conditions have favoured the rapid growth and spread of many of these introduced pests.

Probably the most severe and persistent enemy of the sheep farmer over the past seventy-five years has been the rabbit, and as early as the 1870's some runholders were forced to abandon their land because of its depredations. The question of when rabbits were first introduced into Southland is clouded by conflicting reports, but they were probably imported at several different times by shooting enthusiasts. The worst infestation occurs in the hill regions where farm settlement is less dense and defence against the enemy is poorly organised; but none of the arable or pastoral areas is absolutely free from the pest.

Control of rabbits is a many-sided problem. One factor which has been adverse to a more complete control of the menace has been the market value of the rabbit pelt and carcass. In the year ending 30 September 1949, frozen rabbit carcasses totalling 2340 tons were shipped through the port of Bluff to the United Kingdom. Sixty-one tons of rabbit skins were exported in the same year. The income from this produce is a trifling compensation to Southland for the loss in grazing capacity, increased soil erosion and diversion of man-power. The rabbit will never be eliminated by calling it a pest while treating it as a commodity.

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[9] A. H. Clark has dealt at length with this theme in his *The Invasion of New Zealand by People, Plants and Animals,* New Brunswick, 1949. See especially Chaps. IX and X, pp. 259-292.

Erosion and Flooding

Overgrazing, overburning, overcropping and rabbits have taken their toll of Southland's soil. Denudation of vegetative cover on the hillsides has resulted in the inevitable increase in flood intensities. Nevertheless Southland has suffered less from the ravages of soil erosion than most other parts of New Zealand. On the Southland Plain soil erosion is at a minimum. The land is near-flat or undulating and the large proportion of farm acreages under grass serves to check sheet erosion. The problems of the Southland Plain are concerned rather with the flooding of rivers which have their headwaters in the surrounding hill country, the Oreti and Aparima being the most troublesome. Flooding along parts of the lower Mataura is an annual occurrence. A diversion channel cut by the Southland Catchment Board has eliminated a horseshoe bend north of Mataura Island and besides creating over 300 acres of superior farm land will reduce the flood area along this section of the river. Similar projects to deepen and straighten the channels of main rivers and tributaries have been carried out with the joint aim of reducing the flood hazard and providing better drainage for boglands.

The hill country east of the Mataura is an area of pernicious erosion. The heavy cropping of oats in the late nineteenth and early twentieth centuries on the foothill country set the stage for sheet erosion, and where clean cultivation is practised, soil loss occurs with almost every fall of rain. The affected areas need more grass, more fertiliser and less heavy cropping. If a long term view were taken, trees for timber would be more profitable than either pastures or crops on the steeper hills and in the gullies.

On the Waimea and Five Rivers Plains the light thin soils combine with the drier climate to make these areas susceptible to both wind and water erosion. On the steep hillsides adjacent to these plains the problem is intensified by relief. Southland's outstanding (and logically most serious) example of soil erosion is on Mid Dome Peak about

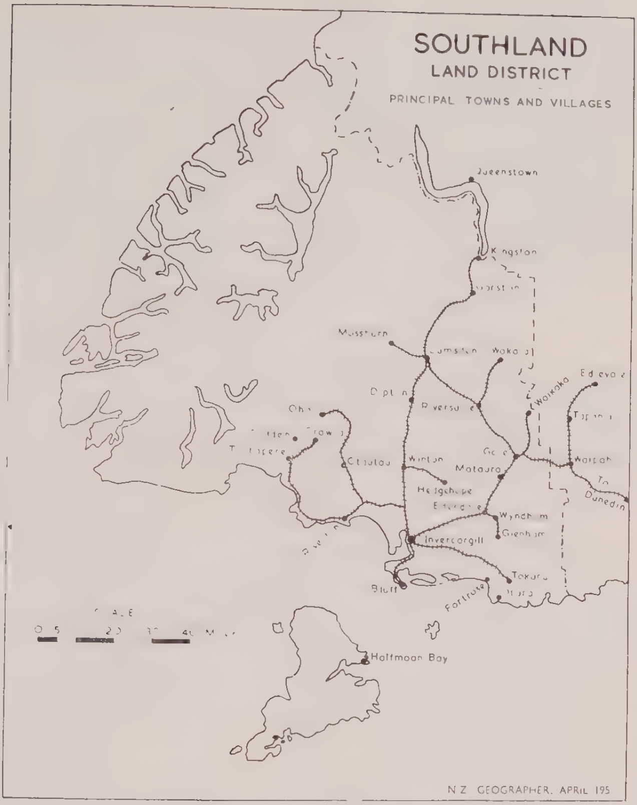

Fig. 5. Southland: Urban Settlement and Railways.

twelve miles north of Lumsden and overlooking the Five Rivers Plain. Gullies, rills, slips, shingle slides, frost heaves and wind scours are all here to scar the hillside. The Soil Conservation and Rivers Control Council has taken over the property for an experimental and demonstration project. After eradication of the hordes of rabbits, estimated at 15,000 in December 1949, growing trials with various types of grasses, shrubs and trees are to be carried out in an attempt to stabilise the slopes.

Prevention of induced erosion and flooding in Southland will entail attention to the causes. Much of the work done up to the present has been on the lower flood plains of streams, but the respite can be only temporary. Rabbit control throughout catchment areas is essential. Burning of tussock grassland is much less prevalent than formerly but the practice still contributes to deterioration of vegetative cover and should be further reduced. One of the reasons, and an ironic one, for less burning on some of the northern and western hill country of Southland is the unfortunate fact that many of the slopes are no longer covered with sufficient tussocks and scrub to burn. The techniques of seeding and topdressing from aircraft can expedite the regeneration of large areas. On areas of broken relief below 2500 feet plantations of exotic timber trees will bring a greater return than grazing and will be instrumental in holding the soil and decreasing flood runoff.

Social and Economic Problems

Southland's agricultural system is more stable than that of most agricultural areas of the world. But it is not exempt from the social and economic trends characteristic of New Zealand, and because of its dependence on overseas trade, its future is closely linked with world economy, and particularly with that of the United Kingdom.

One of the most potent factors gnawing at the foundations of the Land District's prime industry is a twofold trend in population, a trend which is dominion-wide in its effect. There has been a simultaneous drift to the cities and to the North Island from the South Island. Young people in particular have taken part in this migration, making it all the more significant. Both these trends were accelerated during the war and postwar periods and their effect has been to restrict the availability of farm labour, most noticeably on dairy holdings. The causes of this movement are many but fundamentally they arise from the shorter working hours, better wages and better recreational facilities in the cities and industrial areas, most of which are in the North Island. Farmers as a group have taken an unrealistic attitude toward this problem, with the result that the labour shortage has become increasingly acute. While enjoying postwar prices for farm produce they have continued to think in terms of prewar wages. Those employers of farm labour who offer living quarters, wages and working conditions on a basis comparable with urban industries have no difficulty in obtaining labour. Provision for schools, entertainment and recreation in rural areas requires the coordinated effort of the community just as in the cities. There are few parts of agricultural Southland so far from villages or towns as to be isolated from possible community social life. Although there still is room for improvement, most farms are reached by electric power lines and maintained roads. The stable, prosperous character of farming in Southland affords a solid basis for numerous opportunities to make farm life more attractive both for farm labourers and for the children of farmers. Attainment of this objective depends in part on govern-

Figs. 6 and 7. Western Southland. Tuatapere and its 'pioneer fringe'; breeding country near Lake Monowai.

mental policy but in the final analysis it can and it should be put into effect by the individual farm owners and the local rural communities. Beyond this it will be possible to ameliorate the labour shortage to some extent by application of scientific methods and machinery to make more efficient use of the manpower which is available.

Only a small measure of relief from the farm labour shortage is provided by immigrants to New Zealand. These people come principally from the United Kingdom, but several from the Netherlands and the Baltic states have also arrived. Those from the United Kingdom come under the New Zealand Government's immigration scheme and are given financial assistance and free transportation. Since 1945 one hundred and nine immigrants have arrived in Southland, but only twenty-five took employment on farms. In no instance did the arrival of workers other than farm labourers release a New Zealander for employment in agriculture. It is obvious that immigration at this rate will make a negligible contribution to the labour force of Southland.

THE PROBLEM OF MARKETS

A problem always confronting a system of commercial agriculture is that of markets. Fortunately for Southland the United Kingdom has contracted to purchase the whole of New Zealand's meat output until 1955, with the exception of certain token shipments which may be despatched to North American markets. The reduction of meat exports from Argentina to Great Britain has strengthened the markets for New Zealand produce. The demand for wool is indicated by record-breaking prices at sales, and dairy products find markets almost as propitious. The maintenance of these markets at such a favourable level depends on British and world economic conditions.

Although present markets are very satisfactory, developments in synthetic fibres and vegetable oil production may have an adverse effect on wool and butter during the next decade. There seems to be a scant prospect of satiating the world meat appetite in the foreseeable future, but butter has a fully fledged competitor in margarine. Wool fabrics, despite their warmth and absorptive qualities are fighting a hard battle with synthetic fibres.

Of immediate economic importance to Southland agriculture is the problem of obtaining machinery and equipment. Shortages of building materials, fencing wire, cement, drain tiles, tractors, cultivating implements and machinery for land clearance and drainage are retarding improvement and development work. For the most part this situation is the aftermath of war and can be expected to improve with time, as indeed it has in the past five years. The dollar problem has created an obstacle to the importation of machinery, trucks and cars from Canada and the United States in sufficient quantities to meet the demand. Until the disparity in trade figures between dollar and sterling areas is equalised, or the United States artifically closes the dollar gap by means of loans or grants, this problem is likely to persist and retard the increase in agricultural production.

Increasing Agricultural Production

Considered either in relation to area or population Southland produces more than its proportionate share of the world's food and fibre. However, there are still many potentialities for increasing this contribution. The most obvious opportunities for realising these potentialities are in the development of new land. There are large areas in Southland still undeveloped and unproductive. The Awarua Plain-Seaward Bush area between the Oreti River estuary and the Mataura River includes over 90,000 acres of land which could be developed by an extensive (and expensive) drainage programme. Because of the coastal exposure and wet conditions it would be more suitable for dairying than for sheep, but the area has the advantage of proximity to Invercargill and the port of Bluff. Smaller areas of similar land along the coast between the estuaries of the Oreti and Aparima could also be brought into production by means of drainage. The need for an extensive system of drains and the high cost to the individual of draining a farm make necessary the use of heavy machinery. Financial assistance from the government will undoubtedly be required to carry the project through its initial stages, and a prerequisite to settling such areas is a favourable land policy on the part of the government. The Royal Commission on the Sheep-Farming Industry has recommended the establishment of a Marginal Lands Board to assist in the development of lands which over a long period 'would yield sufficient production to constitute an economic gain to the nation if developed, but from which the return in the short period would not be sufficient to enable the ordinary individual farmer to carry out the development'.[10]

In the hill country east of the Mataura and in the hills and terraced valleys west of the Waiau there are several thousand acres of potential pastoral and arable land which are at present forested or covered with scrub and stumps. In view of the present high cost of land clearance some governmental aid will be necessary if frontiers of settlement are to be pushed back in these areas. Considerable expanses of tussock, scrub and bush on the Hokonui Hills could be improved for pastoral production by topdressing, ploughing and clearing. On the rougher parts of this hill country it would be wise to replace cutover forest and scrubland with timber trees.

Better Pastures and Management

In addition to the pioneering of new land much can be done to improve land already under occupation. This is the case in the tussock hill country of northern Southland. Rabbit control, avoidance of overgrazing and overburning, topdressing and surface sowing of high quality grasses can all play important parts in increasing productivity in this type of country. On the more highly productive farmlands of the Southland, Waimea and Five Rivers Plains land development can still be carried out but production must be stepped up principally through better management practices. Most of these practices have already contributed to some extent to the evolution of the present high standard of agriculture, but they need to be carried on to full fruition.

The development of agriculture in Southland has long since reached the stage where the need for scientific research in achieving maximum production is recognised. On the Southland Plain, in particular, simple exploitation no longer suffices to increase yields and the quality of crop and livestock products. Future prosperity stems from systematic investigation into problems associated with soil deficiencies, soil conservation, plant and animal diseases, weed and insect control, improved animal breeds, more productive pasture and crop plants, and the utilisation of byproducts.

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[10] *Report of Royal Commission on the Sheep-Farming Industry in New Zealand,* Wellington, 1949, p. 54

CONCLUSION

The Murihiku of a century ago has developed into a high-producing pastoral region which contributes significantly to the world's food and fibre supply. Yet modern Southland is young—young historically, economically and agriculturally. The production potential has been little more than scratched on the surface. In a world with an ever-increasing demand for food and living space it is difficult to see how Southland can remain underpopulated indefinitely. An increased population is a prerequisite to full realisation of the productive capacity of Southland.

METROPOLITAN AUCKLAND: THE CONTEMPORARY CHARACTER OF A NEW ZEALAND METROPOLIS*

L. L. POWNALL

AUCKLAND is a national metropolis, the largest city and the greatest port in New Zealand. Because of its size alone Auckland is distinctive among New Zealand towns, but its individuality results rather from the integration of many other natural and cultural features. Among the elements most suited to objective analysis, description and evaluation are the physical site, the nature of the contemporary functions performed by the city, and the character of the areas in which such functions are conducted. The streets which interconnect the different functional areas, and the population structure of the metropolis, also contribute strongly to the ensemble of features which together characterise Auckland and distinguish it from all other urban areas. To the casual observer and metropolitan resident, however, few features are more striking than those of the site—the climate with its warm summers and mild winters, and the gentle slopes and volcanic cones of the isthmus.[1]

SITE CHARACTERISTICS: CLIMATE

Metropolitan Auckland has a warm, moist and equable climate; snow is unknown on the isthmus and frosts are extremely infrequent. The city also has a higher mean temperature than most other climatic stations of similar latitude.[2] Associated with the warm temperatures and frequent rainfall is the high relative humidity of the atmosphere.[3] Although maximum humidity prevails in the winter months its physiological effects are most apparent in summer. Auckland does not experience strong winds to the same extent as do the other main New Zealand cities, and because of this the 'sensible' temperatures often appear to be higher than the thermometer actually records. The Auckland city dweller responds to the higher temperatures of December, January and February by dressing more informally than the resident of more southerly towns. But the warmer climate of Auckland has not caused any other modification in the way of life of metropolitan dwellers, nor has it influenced at all the functions which the city itself performs.

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*This is the second of two papers on Metropolitan Auckland. The first, on the historical evolution of the city, was published in the *New Zealand Geographer,* Vol. 6, No. 2, September 1950, pp. 107-124. The research was made possible by a grant awarded by the University of New Zealand Research Grants Committee to whom grateful acknowledgement is made.

[1] The surface configuration and geology of the Tamaki isthmus was described broadly in the first part of this paper.

[2] Extreme max. 86.5°F, extreme min. 32.2°F, yearly mean of days with ground frost 1.7: recorded at Albert Park, Auckland; period of record 26 years; elevation 160 feet. See E. Kidson: 'Climatic Notes: New Zealand Districts', *N.Z. Met. Office Note No. 17,* 1937, p. 20.

[3] Mean relative humidity at Auckland, 9 a.m. 75 percent, *ibid.,* p. 30; annual average rainfall, 49.4 inches.

Functions of Auckland

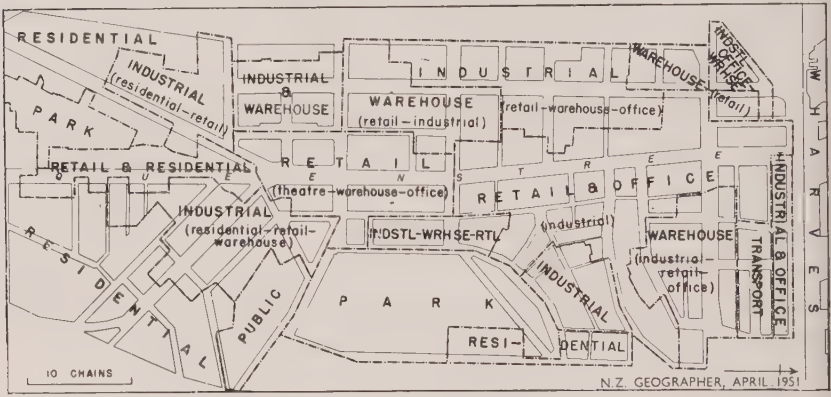

Fig. 1. The Central Core: Land-Use Areas.

Metropolitan Auckland is first an industrial city, second a commercial centre, and third a social and transport focus. Industrial and commercial workers together comprise seventy-five percent of all Auckland employees.[4] Of the remaining workers the largest group of persons employed in tertiary industries is engaged in the provision of social services, although the number in both transport and administration is almost as large. In Metropolitan Auckland, however, transport is of greater importance than the criteria of number of employees would suggest, for the economic life of the whole city is largely dependent upon the seaport. The airport at Whenuapai is the terminus for land planes from North America while the Waitemata Harbour is the main New Zealand terminus for the daily transtasman flying-boat services and the only port of call in this country for passenger vessels plying between Australia and North America. Within the boundaries of Metropolitan Auckland different areas perform each of these main functions of the city. Although such areas in general are concerned with one type of land use, a few are composite in character.

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[4] Out of every hundred employees in Auckland, forty-nine are engaged in industry, twenty-seven in commerce, nine in social services (entertainment, medicine, education and religion), seven in transport and one in the maintenance of utilities. (All statistics relating to employment in this paper have been compiled from the individual half-yearly returns of employment made to the National Employment Service of the Department of Labour and Employment and published in April 1947. The cooperation of officers of this department is gratefully acknowledged.)

COMPOSITE LAND-USE AREAS

The most extensive and distinctive composite area is the central core which is in the Ligar Valley[5] (*Fig.* 1). In this compact district specialised areas may be recognised by the predominance of one or more functions. Lying almost exactly north and south along the floor of the valley, Queen Street dominates the retail area. Shopping areas of secondary importance extend for only short distances along three of the major cross-streets. Above the ground floor level in Queen Street, and interspersed among the offices and warehouses of the central core, are numerous small factories. Commerce and industry are of almost equal importance, employing respectively 49.3 percent and 49.05 percent of all workers. Surrounding this main retail street are areas of mixed function and buildings of varied elevation. Because of the steep nature of the valley, the urban skyline here appears to be low when viewed from the surrounding ridges, in spite of the height of buildings along the valley floor (*Figs.* 1 and 2). In contrast to the dispersed nature of industry, picture theatres are located together in the central part of Queen Street. The central core is also the focal point of all tramway, bus and ferry services. As a result of this, and of the attractions of the amusement theatres and shop windows, this main street is a busy area by comparison with other parts of the city at weekends and on holidays.

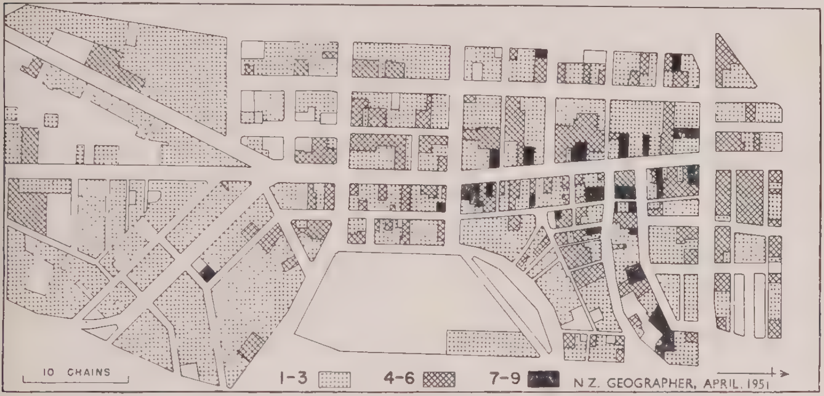

Fig. 2. The Central Core: Height of Buildings (in storeys).

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[5] 38.19 percent of all employees in Metropolitan Auckland work here; 2.37 percent work in the Newmarket area and 1.26 percent in the Karangahape Road district.

Within the central core are many poorer grade accommodation houses; in some cases beds, but not rooms, are hired overnight. More licensed hotels and residential clubs are located here than in any other district. Single residences are infrequent, except in the southeast of the central core, although rooming houses, often accommodating elderly people, are more common. The Queen Street area is also the centre for administration in Metropolitan Auckland and here most local authorities and all government departments have offices.

To a greater extent than in the central core, the Newmarket composite area is predominantly industrial in character, with eight out of every ten workers employed in manufacturing. The retail area is concentrated in one thoroughfare, Broadway, between the railway and the northeastern slopes of Mount Eden. Here, the buildings are generally of one or two storeys only, and are used predominantly as shops. Offices and warehouses are relatively unimportant, while factories are located outside the retail area. Newmarket does not consist wholly of contiguous areas of retail shops and factories. Residences of varying ages and values are scattered throughout the borough. Newmarket is also the nexus of five major roadways, all of which carry frequent tram and metropolitan bus services; as a result an important characteristic of this district is the 'bottleneck' of Broadway where road traffic is compressed into one busy shopping street.

Karangahape-Newton is the smallest of the major composite areas. By contrast with both the central core and Newmarket which are located in small valleys, this area extends along the crest of a ridge. The resultant linear form is thus more marked than in the other two areas. The retail area here consists predominantly of single and two-storey buildings. Although still primarily industrial in character, Karangahape-Newton has a relatively larger proportion of workers employed in commerce than is the case in Newmarket.[6]

Industrial Areas

In addition to these districts of composite land use, fifteen distinctive areas may be defined in Metropolitan Auckland in which industries are the predominant function (*Fig.* 3). The major area, measured by the number of employees, is the central core. Of the twenty-eight percent of Auckland industrial employees who work in this area, more than one third is engaged in the manufacture of clothing, for

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[6] Percentage of total employees in commerce in each area: Central core, 49.3; Newmarket, 16.19; Karangahape-Newton, 46.54.

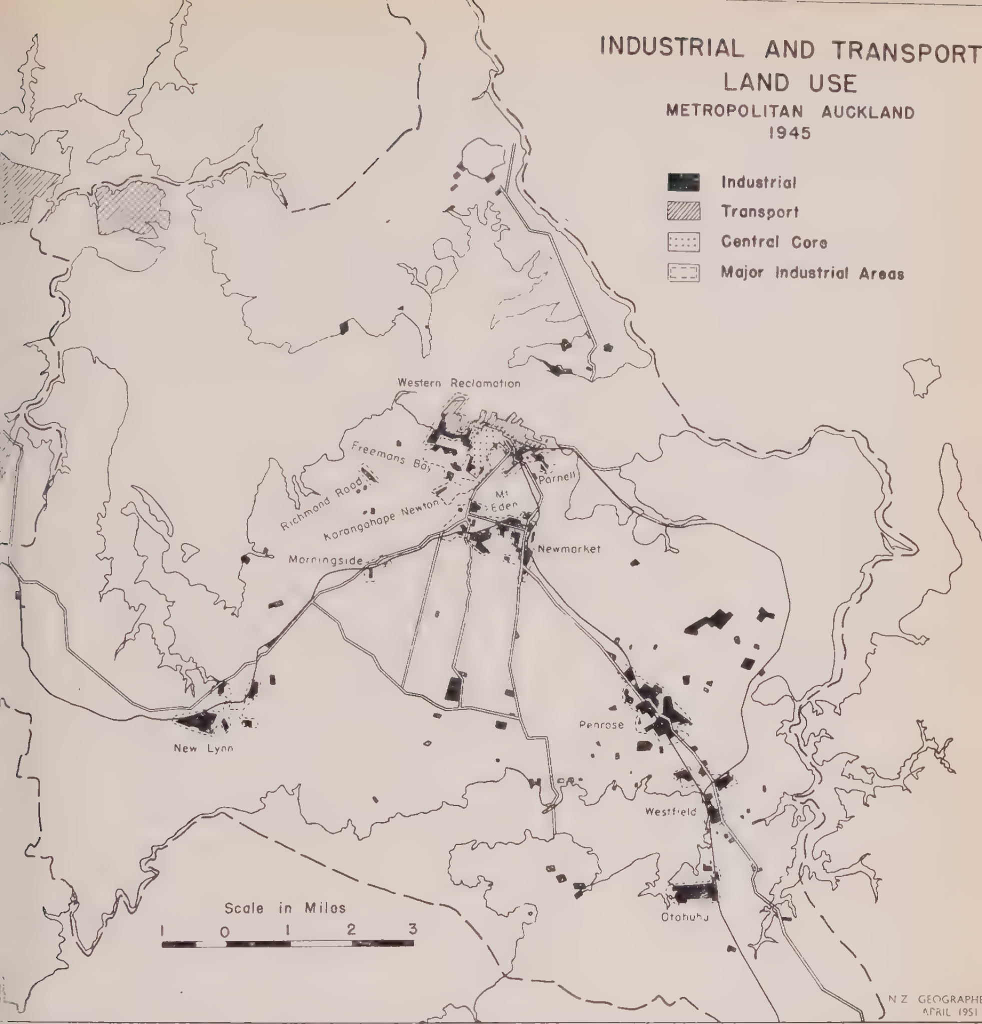

Fig. 3. Metropolitan Auckland: Industrial and Transport Land-Use Areas.

the central area is the main sewing district in Auckland and employs more operatives in this category than all other industrial areas combined. Light industries of this type are concentrated in buildings in and adjacent to Queen Street, while the heavier industries and those requiring more space have locations outside the central core.[7] Within the central district, however, there is little functional specialisation in industrial areas other than in the broad differences between heavy and extensive and light and intensive industries.[8]

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[7] Industries in the central area employing more than 75 percent of all Auckland workers for that type of industry are grain milling, 89 percent; biscuit making, 91 percent; tobacco preparation, 100 percent; printing, 87 percent; fur making, 89 percent; artificial textiles, 100 percent; woollen mills, 78 percent; general machinery, 77 percent. (The definition of industrial groups used in this paper are those employed in the National Employment Service codes. *Figs.* 3 and 4 are based upon a map drawn by the Auckland Metropolitan Planning Organisation.)

[8] Percentage of workers in classes of industry in central area: Light, 76.3; Heavy, 23.6; Noxious, 0.1. (Definition of classes adopted from Civic Survey Notation, Town Planning Section, Ministry of Works.)

Of the other fourteen areas only Newmarket is at all comparable with the central district in the number and diversity of its industries. Newmarket is the second largest industrial area but, unlike the central core, engineering is the major industry, with the manufacture of beverages and the maintenance of vehicles next in order of importance. In contrast to the central area the majority of these factories, as already noted, are located in separate buildings outside the retail district.

Westfield is distinguished by one type of industry and the large size of the factories. This area is devoted to the preparation of meat and to the related industry of treating chemical and animal products. The individuality of the area lies also in the blemished appearance of the nearby holding paddocks and refuse areas, and in the repugnant smell and the unsightly landscape of mud flats and discharge pipes.

Although Penrose was only the fourth largest factory district in 1947, it is expanding more rapidly than any other area. Factories here are generally of recent construction and the units are large by New Zealand standards, particularly among the leading industries of timber processing and the manufacture of glass and rubber goods.

In the Freemans Bay industrial area, contiguous with the central core, engineering and metal products predominate, although clothing manufacture is also important; but in terms of its metropolitan significance, this area is distinctive because of the relative importance of the manufacture of jam and condiments and of miscellaneous textile goods.[9]

In the fifteen industrial areas which have been recognised in Metropolitan Auckland, only three consist predominantly of light industry; the two largest of these are located around the major retail areas and are without direct access to rail facilities. Only the Westfield area is noxious in character, although the tanneries of New Lynn and the fertiliser works at Otahuhu make these areas partially noxious. The

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[9] The other ten industrial areas in order of importance are:

(i) Otahuhu (railway workshops).
(ii) Mount Eden (woodwork, general engineering, vehicle maintenance, footwear).
(iii) Parnell (general engineering, footwear, confectionery, wool stores).
(iv) Western Reclamation (general engineering, ship repairs, boat building).
(v) Karangahape-Newton (clothing, footwear, furniture).
(vi) New Lynn (pottery and glass, tanning, textile articles).
(vii) Devonport (repair of naval vessels).
(viii) Chelsea (sugar refining).
(ix) Morningside (chemicals, footwear, wooden articles).
(x) Richmond Road (leather processing).

Detailed tables have been prepared for all industrial areas showing the percentage of total Auckland industrial employees in each area, the percentage of employees in each industrial area working in different industries, and the percentage of total employees for Metropolitan Auckland in different industries working in each area. These have been omitted from the present paper because of the pressure upon space.

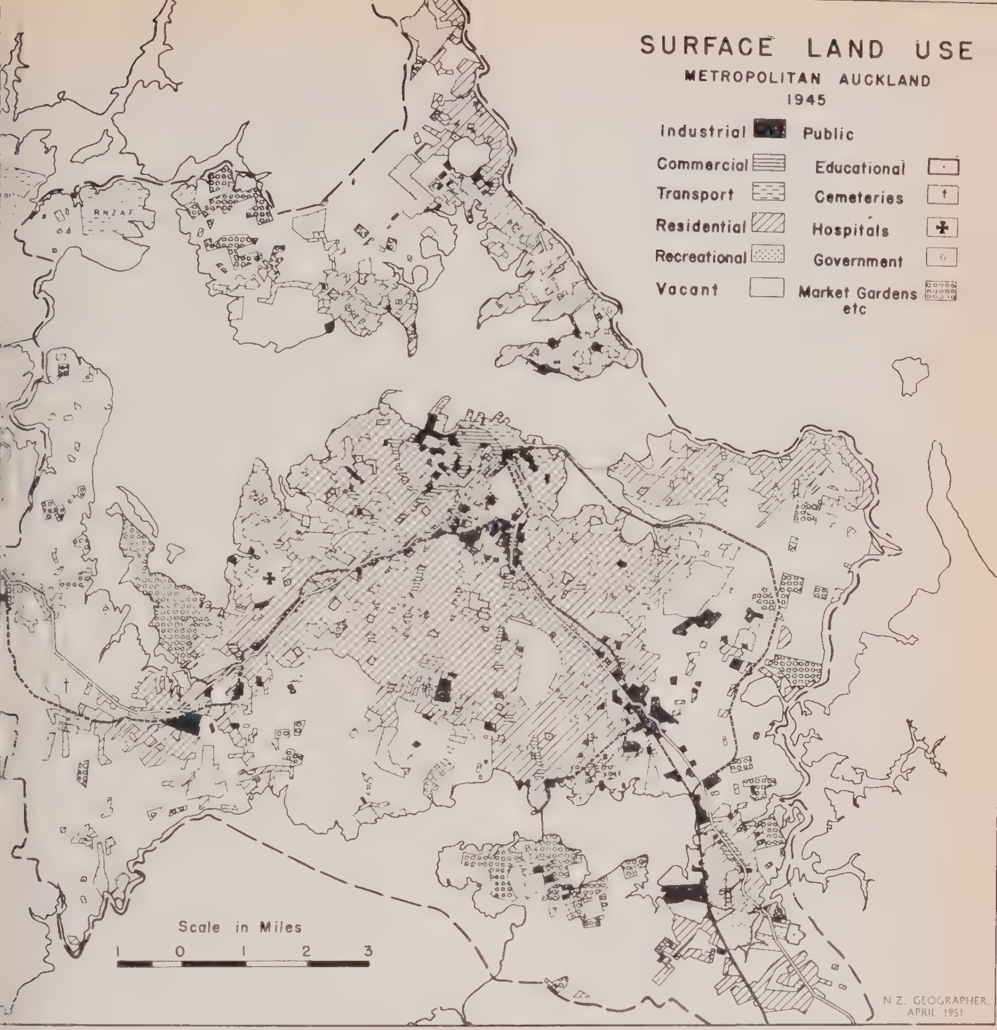

Fig. 4. Metropolitan Auckland: Surface Land-Use Areas.

majority of the manufacturing areas, however, are of a heavy industrial nature and are located, almost without exception, near railway lines or on deep, tidal water.[10] Within or adjacent to most of these industrial districts are shopping areas which serve the factory workers as well as the neighbouring residents.

COMMERCIAL AREAS

In Metropolitan Auckland commercial areas are more uniform in character than industrial areas. With the exception of the central core all the commercial districts are linear in form although located at the junctions of major thoroughfares (*Fig.* 4).

Despite the fact that the central core dominates the commerce of Auckland and employs more than sixty-two percent of all metropolitan commercial workers, it is not predominantly a retail district but an office centre. No less than thirty-nine percent of all commercial workers in this area are employed in offices, for here are located the headquarters of all metropolitan banks, the offices of the insurance firms, and the Auckland Stock Exchange. In addition to these workers thirty-one percent of commercial employees are shop assistants. This is also the main warehouse centre for the metropolis, with twenty-five percent of all commercial workers engaged in this one branch of trading. The majority of eating places, and all the stock and station companies and commercial education businesses are also located within the central district. It is this great volume of workers, with their fellow employees in industry, who congest the early morning and late afternoon transport services and crowd the streets of the retail area in the middle of the day.

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[10] It should be noted that twenty-five percent of all industrial workers in Metropolitan Auckland are employed in scattered factories outside the fifteen areas defined in this paper.

The Queen Street Focus

Functional attraction among certain retail and commercial businesses occurs within the central core.[11] Queen Street, as the main office and retail area of the central core, is characterised by the height of the buildings and by valuable building lots. The marked difference in the value of land in areas immediately adjoining this street reflects the relative lack of competition for sites other than in Queen Street. The central commercial area is also distinguished in northern Queen Street by the three large shopping arcades which extend to floors above the level of the street. The change within Queen Street from blocks of retail shops to extensive banking, insurance and general office buildings is particularly marked on the western side of the street.[12]

The Karangahape-Newton area, although it is the second largest commercial district, has only half as many commercial workers as the central core, or five percent of the Auckland total. Retail buildings in the eastern half of the area are of an equivalent size to those of Queen Street firms; apparel shops as a group have the largest total of employees, department stores and 'chain variety shops'[13] are significant in the retail structure, and provision stores are of relatively minor importance. The tall and distinctive office buildings which dominate the central core are absent.

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[11] Stock and station firms are situated in northern Albert Street, greengrocers and butchers are grouped at either end of the retail area, and pawn shops are located together at the southern end of Queen Street and in Victoria Street West. The majority of automobile agencies are confined to Albert Street on the crest of the western ridge which encloses the commercial core.

[12] A possible explanation of this fact is the number of non-retail buildings which interrupt the continuity of shop window space and protecting verandahs, thereby reducing the attractiveness of this side of the street for shoppers. Verandahs, or permanent awnings, are typical features of all New Zealand retail areas.

[13] 'Chain variety shops', by contrast with department stores, have counter displays and non-bulky goods only—haberdashery, kitchen hardware, stationery, confectionery and cosmetics among others.

Among the suburban and district centres Newmarket has only a little more than half of the number of commercial employees that Karangahape Road has. More than eighty-three percent of all commercial workers in Metropolitan Auckland are shop assistants, with clothing and food stores employing almost half of this number. The most important commercial activity in the Upper Symonds Street area, however, is the sale of furniture. Wholesaling establishments, related in many cases to the furniture trade, make this the second largest wholesale centre in Metropolitan Auckland. Indicative of its transitional character, employees in provision stores outnumber those in clothing shops although offices are still of considerable importance, particularly in banking and general finance. Otahuhu, in the south-eastern part of the metropolis, is smaller than the areas so far discussed and in functional character is comparable with Newmarket.

Suburban Shopping Areas

Suburban shopping areas in Metropolitan Auckland have developed a discontinuous 'shoe-string' form along the main roads, with a nucleated pattern at focal points in residential areas. In function and composition, local shopping areas are remarkably uniform.[14] Provision stores are the principal shops, employing in general at least fifty percent of the workers. Grocery, clothing, 'service' shops, green-grocers, chemists, home cookeries and petrol service stations form the bulk of retail establishments in these areas; by contrast offices are relatively unimportant.[15] All too frequently these local shopping areas of high building density, and the residential districts which surround them, lack adequate public parks and gardens. The general absence of trees from the commercial districts in Auckland makes the provision of contiguous open spaces even more desirable.

Although approximately twenty percent of the surface of Metropolitan Auckland is devoted to public open spaces, including hospitals and schools, the amount of land available to the public for recreational purposes varies considerably from district to district (*Fig.* 4). Only one extensive open space is located within a radius of two miles of the northern part of Queen Street; this is the Auckland Domain. An unfortunate lack of foresight by early administrators has resulted in the siting of two cemeteries adjacent to the southern part of the central business area. These have long since become disused, unsightly, and wasteful of surface. In striking contrast are the gardens and lawns of Albert Park, two blocks east of Queen Street. In spite of the maldistribution of open spaces, the inner area is an important recreational centre since it contains the major facilities for yachtsmen and launch owners in Metropolitan Auckland.

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[14] Many proprietors of neighbourhood shops do not employ assistants and are therefore not included in the National Employment Survey.

[15] More than seventy percent of all food shops are located in neighbourhood retail areas. Equally high percentages would probably apply for all types of shops listed above with the exception of clothing, 'service' shops (hairdressers, chiropodists, etc.), and chemists.

In the intermediate belt two to four and a half miles distant from Queen Street, the majority of the areas dedicated to public use are located on the southeastern perimeter and in the extreme west where much of the land is occupied by a psychiatric hospital and the Auckland Zoological Gardens. Except in the southeast the outer area is well provided with recreational facilities, but in view of the rate of expansion of residences into this zone, the open spaces set aside at present are meagre and poorly distributed for future needs.

Metropolitan Auckland is also characterised by the attractiveness of its many public beaches around the Waitemata Harbour and on the neighbouring small islands in the Hauraki Gulf.[16] In Auckland, more than in any other New Zealand city, the people are conscious of the potentialities of the harbour for recreation, and on summer weekends the Waitemata is dotted with the sails of small craft and the beaches are crowded with people.

SCHOOLS AND CHURCHES

Educational and religious institutions are the most common and widely distributed of public areas in Metropolitan Auckland.[17] Ten schools are located within the inner area already defined, not primarily through the central location of this area, but because of geographic inertia. The schools of the intermediate and outer belts are generally of more recent construction than those of the inner area, and at the same time are better provided with open spaces. By contrast with the even distribution of schools, the other institutions of general education, such as the War Memorial Museum, Public Library, Old Colonists' Museum and Art Gallery, are concentrated within the inner area. Churches are even more omnipresent among the public land-use areas than are the schools of Auckland, although only one church remains in Queen Street. Elsewhere in the inner section at least four important churches, which were once surrounded by residences, have been engulfed by the expansion of commercial building.

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[16] The pollution of the waters of the Waitemata by sewage, however, has restricted the use of these beaches in recent years.

[17] Altogether 107 primary and 24 postprimary schools provide for the basic educational needs of Auckland. Auckland University College is one of the constituent colleges of the University of New Zealand.

Five public hospitals serve this metropolis, two being located within the inner area. There are, in addition to these extensive public institutions, some fifty-five private hospitals, of which six are situated within the inner area and seven are on the North Shore. Of all the public areas, however, the most highly localised are those in the central core which contains nearly forty percent of the theatres, cabarets and amusement parks.[18]

Administrative Areas

Metropolitan Auckland is administered by twenty-three city, borough and county councils. The number and disproportionate sizes of the different administrative areas, both in population and acreage, and the patternless mosaic of the areas themselves, point to inefficient and uneconomical features of Auckland. By contrast with the duplication of borough authorities, the majority of the other local bodies have jurisdiction over the whole metropolis, although their boundaries rarely coincide with the limits of Metropolitan Auckland or of each other, but vary from the area of the Auckland Land District to a portion of the metropolis only. The problems and weaknesses resulting from such a system of local administration can be recognised more easily than they can be resolved.

The administrative offices of all metropolitan local bodies and of some adjacent county councils are located within the central business area; here are the seats of transport, harbour, drainage, education, electric power and fire boards. In administration, as in other urban functions, the central core has attracted the majority of the office workers, while the garages, yards and bulk stores for local authorities are located outside this area.

Because of its size, Auckland is a main centre for administration by the dominion government and few departments of state do not have branch offices in the city. With only one or two exceptions all of these offices are located in the Queen Street area. At the same time it should be noted that no single district within the central core is distinctly concerned with administration. In addition to the offices of local and national government, many commercial businesses with nation-wide interests also have their headquarters in Auckland. These firms are concerned with importing goods or with the distribution of local manufactures rather than with head office administration for other centres throughout New Zealand. The establishment in Auckland of many of these firms is related in large part to the importance of the metropolis as a centre for collection and distribution, a transhipment point between overseas and local markets.

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[18] With forty-six picture theatres, Auckland has approximately one theatre for every 6,500 residents. Picture theatres in the central core have four screenings every day, excluding Sunday, when city by-laws require all places of entertainment to be closed.

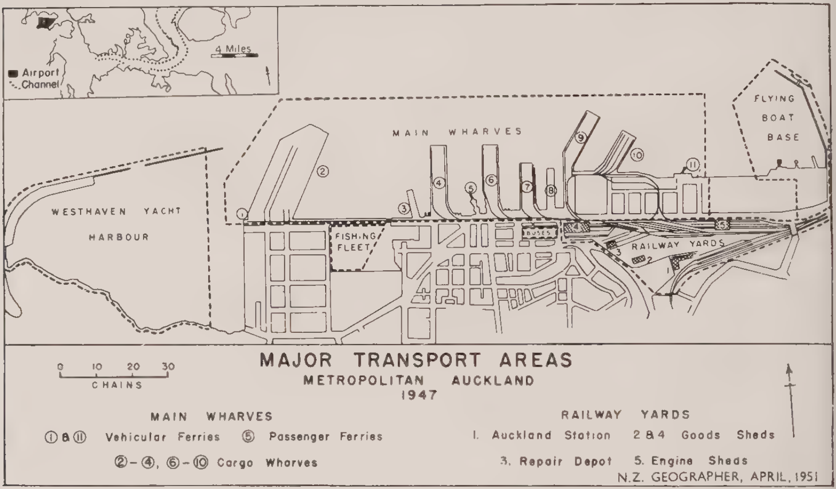

Fig. 5. Major Transport Areas of Metropolitan Auckland.

TRANSPORT AREAS

Sea, rail and road transport systems converge on the central core. Here they occupy contiguous areas along the southern shore of the Waitemata. The entrance to the port of Auckland follows the Rangitoto Channel, a dredged course approximately one mile wide and four miles long, trending north and south between the island of Rangitoto and the Takapuna-Devonport peninsula. Within the harbour are the explosives anchorage in the eastern sector, the main harbour works along the southern shore, the sugar wharves in the northwest, and the naval dockyards on the southwestern coast of the Takapuna-Devonport peninsula.

Of the total cargo handled by the port of Auckland in 1946–1947, ninety-four percent was shipped or discharged in the main harbour area. The main wharves, extending for over two miles along the shore of the Tamaki isthmus, consist of four different harbour areas of which the most recent is the flying base[19] (*Fig.* 5). The fishing fleet anchors in a small enclosed harbour adjacent to the produce and fish markets, whilst in direct contrast with this commercial function is Westhaven, the anchorage for most launches and yachts. But it is the main wharves which dominate the Waitemata waterfront and constitute the *raison d'être* of Auckland. In 1947 the port of Auckland handled thirty-six percent of the total external trade of New Zealand by value of goods, four percent more than the next largest port, Wellington.[20] Operating primarily as an importing centre, Auckland serves the greater part of the North Island through its rail and road transport network.[21]

The most important railway area in the metropolis lies between the northeastern section of the central core and the eastern harbour area[22] (*Fig.* 5). Among the railway stations of New Zealand, Auckland ranks first in tonnage of goods handled, and second, after Wellington, in the number of passenger tickets sold. The nature of the tributary region served by the railway is shown by the importance of wool, frozen meat, dairy produce, timber and coal in the rail traffic of this station. It is also the passenger terminus for express trains to Northland, Rotorua and Bay of Plenty centres on three days of the week, to New Plymouth twice each week, and for the thirteen express trains which travel overnight each week between Auckland and Wellington. The main bus terminus for the metropolis occupies a site between Queen Street and the railway yards and from this depot road services operate five days a week to centres as far apart as Napier, Gisborne, Taumarunui, New Plymouth and Kaitaia.[23]

Whenuapai airport lies two miles beyond the western boundary of the metropolitan area. In addition to the fact that the airport is fifteen miles from the centre of the city, Whenuapai also suffers from the disadvantages of hills in the vicinity and of both civil and

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During 1947-1948, nearly 19,000 passengers passed through Mechanics Bay on the Auckland-Sydney flying-boat service which operated eight return trips each week. Less than 100 tons of freight were carried over the same period and only 150 tons of mail.

See Census and Statistics Department: 'External Trade and Shipping, 1948', Supplement to *Monthly Abstract of Statistics*, May 1949, p. 6.

Industrial materials form the bulk of this trade, chiefly petroleum, coal and manures. The major exports are pastoral products from the dairy lands of the Waikato, Bay of Plenty and Northland, and from the sheep country of the northern half of the island.

On this reclaimed land over thirty-three acres have been developed for railway purposes—for marshalling yards, engine sheds, goods sheds, a repair depot, and the station itself.

Approximately eighty buses leave this terminus each day for towns outside the metropolitan area and beyond the limits of daily commuting.

military use of the aerodrome. From Whenuapai in 1947 trunk services operated two flights each day (excluding Sunday) to Dunedin, Gisborne, Wellington, and Christchurch, and one to Kaitaia.[24] Compared with sea and rail transport, however, air services are of only secondary significance in the economic life of the metropolis. At the same time the place of Auckland in 1947 as the only New Zealand overseas airport and the terminus for five national air services adds to the distinctiveness of the metropolis as the major transport centre among New Zealand cities. Equally distinctive is the movement of traffic along the streets of the metropolis itself.

The Movement of Auckland Traffic

Because of the concentric form of Auckland and the division of the metropolis into two parts by the Waitemata Harbour, road and water services are of greatest importance in transport.[25] Within two miles of the central post office six major routeways may be defined; all are radial streets, four proceeding in a southerly direction and two trending east and west (*Fig.* 6). As a result of the convergence of these routes there is a concentration of vehicles in Karangahape Road, Upper Symonds Street and Newmarket, the last having the highest volume of traffic in Metropolitan Auckland. Beyond a radius of two miles the traffic separates into eleven major outlets. The composition of this traffic varies from street to street and the volume from hour to hour.[26] With two exceptions all the main roads on the isthmus, both radial and concentric, connect the port with industrial areas in the southwest and southeast, or link manufacturing area with manufacturing area.

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[24] In 1947-1948 a total of 18,996 passengers used Whenuapai for these internal services and a further 3,297 for overseas flights to the U.S.A. and Canada. Whenuapai is the New Zealand terminus for these overseas flights which included, in 1947, three flights every fortnight to San Francisco and Vancouver via Fiji, Canton Island, and Honolulu. By comparison with rail and road services from Auckland, which have not increased between 1947 and 1950, both internal and external air services have been more than trebled in number.

[25] On the isthmus road traffic is mixed, comprising buses (2 percent), motor cycles (3 percent), trams (5 percent), motor trucks (23 percent), and taxis and cars (53 percent). Few bicycles (only 13 percent of the total traffic) face the dangers of the Auckland streets and the frequent steep inclines (*Traffic Survey, 1938,* Auckland City Council, p. 7). *Fig.* 6 is copied from this survey and grateful acknowledgement for permission to use it is made to the Auckland City Council.

[26] Although automobiles are common to all routes, the traffic along the waterfront causeway consists predominantly of cars and buses; no trams and relatively few trucks use this route. Along Remuera Road trams replace buses while motor trucks are still relatively insignificant. In three of the main radial streets of the inner area (Parnell Road, Symonds Street and Hobson Street), the traffic is predominantly commercial. Both Symonds Street and Karangahape Road are characterised more than any other outlet by the volume of bus traffic. At the other extreme, all buses are excluded from Queen Street. Between 7.30 a.m. and 8.30 a.m. each weekday approximately 27,000 people enter the central core, while 29,000 depart between 4.30 p.m. and 5.30 p.m. Of this total no less than fifty-five percent pass through the Upper Symonds Street and Karangahape Road retail areas. (Calculated from *Enquiry into Future Development of Railways in Metropolitan Auckland,* Auckland City Council, 1949.)

Although the largest volume of commercial traffic avoids the lower levels of the Ligar Valley by following the neighbouring ridges, vehicles which serve shops, warehouses and industries in the central core block the narrow side streets between 8.00 a.m. and 5.00 p.m. when the only deliveries are made. At night these streets are deserted by trucks which in overseas metropolitan centres would be servicing the commercial hearts of cities in preparation for another day. The 'natural' grouping of industry and commerce around the port has also produced dislocation of freely moving traffic. This is the result not so much of the surface configuration of the inner area as of the legacy from the past of a complex of narrow streets and lanes. At the same time the problem is increased by the parking of cars even in the narrowest of streets.

In no other urban area in New Zealand is the movement of people by water transport as important as in Metropolitan Auckland.[27] In

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[27] Nearly 29,000 people travel each day between the two shores of the Waitemata by passenger ferry boats. Of the total number of people entering the central business area by commercial transport on an average weekday between 7.30 a.m. and 8.30 a.m., nineteen percent are carried by ferry steamers from North Shore. By comparison fifty-two percent travel in trams, twenty-two percent in buses, and only six percent in trains (*Enquiry into Future Development of Railways in Metropolitan Auckland*, Auckland City Council, 1949).

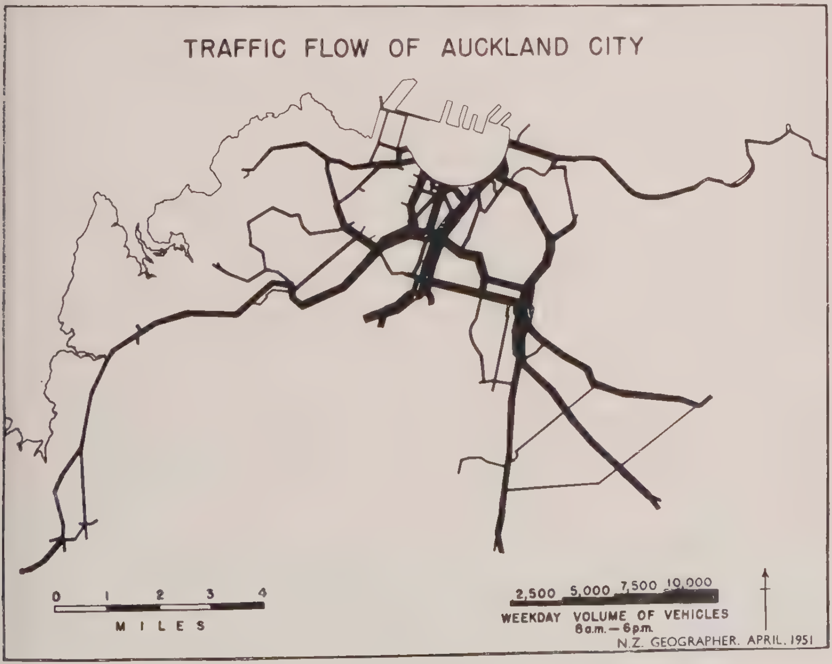
TRAFFIC FLOW OF AUCKLAND CITY
0
1
2
3
4
MILES
2,500
5,000
7,500
10,000
WEEKDAY VOLUME OF VEHICLES
8a.m. — 6p.m.
N.Z. GEOGRAPHER. APRIL, 1951

Fig. 6. Flow of Road Traffic in the City of Auckland.
(Suburban boroughs were omitted from the survey.)

addition to the passenger services across the Waitemata, vehicular ferries ply between Devonport and Birkenhead and the respective wharves at the eastern and western extremities of the main harbour works. On the North Shore the two major roads terminate at the vehicular ferries. In place of trams, buses operate complementary services with the passenger ferries and form an appreciable proportion of North Shore road traffic. Here, however, the streets are more suburban in character than are those on the isthmus which are an equivalent distance from the harbour.

RAILWAYS LOCALLY INSIGNIFICANT

Compared with road and water transport, railways are of relatively little significance today within the metropolis. The greater proportion of passenger traffic on the suburban rail services is carried from the city to the 'dormitory' towns of Papakura, Manurewa, Papatoetoe and Otahuhu to the south. The importance of rail transport to Auckland therefore lies not so much in the movement of goods and people within the metropolitan limits as in the transport of freight and passengers between the metropolis and other centres. Bus services, on the other hand, are concerned predominantly with carrying city dwellers from their homes to the commercial and industrial sections of Auckland. The routes followed by buses and other road traffic today are in turn related to the pattern of Auckland streets and the influence of the physical site.

PATTERN OF AUCKLAND STREETS

With the exception of the main radial thoroughfares leading into the city proper the streets of Auckland form no clear pattern. Historically these roads followed the crests of ridges and the valley floors; they have remained in use and now dominate the existing street system in the older areas. The movement of traffic is greatest along these streets of easier gradient and tends to avoid the steep slopes of many of the roads crossing the valleys. To the extent that retail areas have developed at the junctions of major routes, the present land use in Auckland is sometimes related indirectly to man's adaptations of the original site.

In Auckland the problems of reticulation of water supply and of sewage disposal have frequently been accentuated by the ridge and valley character of the metropolitan area. The spread of housing into some districts in the southeast has possibly been retarded by the unfavourable nature of the site where scoria has covered the land and where industry is now developing.[28] In contrast to residences, industry has tended in the past to avoid the valley slopes and to concentrate on the lower, more extensive areas.

The most striking modifications of the site of Auckland have been the reclamation of large areas in the districts of original European settlement. The filling-in of swampy areas, as at Newmarket and in the central part of Queen Street, has further modified the natural site, and the gradients of several of the streets leading from the Ligar Valley have also been reduced. Not all modifications, however, have been beneficial, for the quarrying of scoria has resulted in the destruction of several small volcanic cones in the southern part of the isthmus. Although the features of surface configuration are still of considerable importance in the development of the most desirable residential areas, in commerce and in industry local relief is of less significance today in Metropolitan Auckland. Nevertheless, the necessary adaptation of streets to surface configuration made earlier in the growth of the metropolis has influenced present distributions. Surface configuration and structure are the only physical features which have produced extensive adaptation and modification. Even the influence of soil on the location of commercial orchards and market gardens is of negligible importance today.[29] The influence of site, therefore, exists mainly as a legacy from the past although it is still of direct importance in its influence on the location of certain grades of residences.

RESIDENTIAL AREAS

The different residential areas of Auckland are both complex and asymmetrical in their pattern of distribution and contrasting in their composition[30] (*Figs.* 7 and 8). On the Tamaki isthmus, three broad divisions of residences may be recognised: first, a belt of varying width and complex composition parallel to the northern coastline; second, a broader belt along the southern edge of the inner area consisting of two main grades of houses; and third, the complex distribution of

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[28] Initial disabilities for farming purposes and advantages of location for factories led to later use by noxious industry with consequent depreciation of the neighbouring areas for residential development.

[29] The most fertile farmlands on the isthmus have been engulfed by the expanding residential areas or have been zoned for future development as port and industrial areas.

[30] In order to differentiate among the various grades of residences, the criteria of value of residences (excluding plot value) as at the 1942 controlled level has been used in this paper. Grade A: more than £4,000; B: £3,000–4,000; C: £2,000–3,000; D: £1,000–2,000; E: £500–1,000; F: less than £500. Appreciation is expressed for the help given by the staff of the Valuation Department, Auckland, in defining these areas.

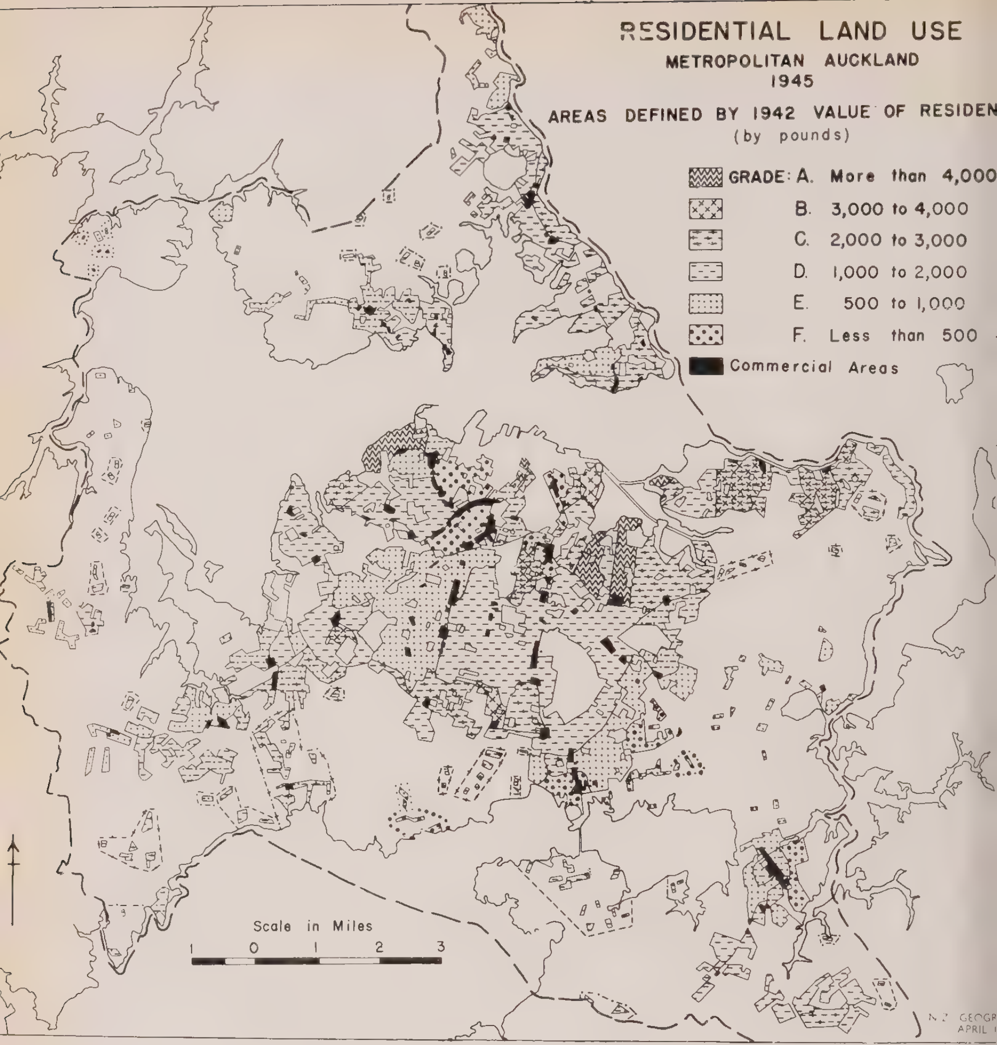
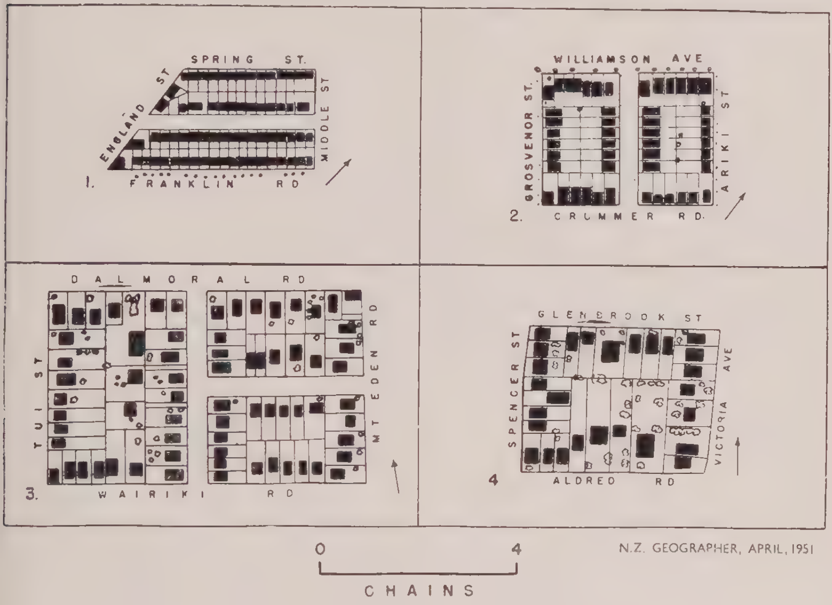


Fig. 7. Metropolitan Auckland: Residential Land-Use Areas.

mixed grades of residences along the perimeter of contiguous residential development and along the radial outlets to the southwest and southeast. On the North Shore the distribution of residential areas is more uniform and orderly.

In the development of the present morphology of Metropolitan Auckland the most valuable residences have been built on the high slopes of ridges and headlands on the northern coast of the isthmus where both view and ready access to the city proper are combined, and in the multi-apartment district on the northeastern fringe of the central core. The single-unit residences are uniformly large, consisting of two or more storeys, frequently of brick construction, and set in extensive grounds. Shrubs and trees are typical features and usually brick walls or high hedges give maximum privacy. The streets within these areas are curved, the *cul-de-sac* is common, and through traffic on other roads is generally insignificant.

Residences of lesser value occupy the floors and lower slopes of the valleys and the areas of little local relief. The bulk of existing houses in Auckland were built during the first quarter of this century on the gently undulating lava flows in the central and southwestern parts of the isthmus. Today they form continuous expanses of residences which are uniformly set back from the footpath and are characterised by small front lawns, wooden fences and a conspicuous lack of trees or large shrubs. The slight variations in architecture from house to house break the monotony of these expanses, while the red and green roofs of galvanised iron and the cream wooden walls of the houses give colour to the urban landscape.



N.Z. GEOGRAPHER, APRIL, 1951

Fig. 8. Typical Residential Blocks. Categories: 1—F, < £500; 2—D, £1000-2000; 3—C, £2000-3000; 4—A, > £4000. (Refer to *Fig.* 7.)

In the oldest residential areas where commerce and industry have not completely replaced the original function, the expectation of changes in land use, combined with the natural decay of buildings, have produced areas of urban blight. The most decadent of these areas in Metropolitan Auckland are located on both sides of the Ligar Valley and within one hundred yards of the Auckland Town Hall and City Offices. Similar areas are found in other parts of the isthmus.

Here the roofs of the houses are rusted and brown; the walls are bare of paint; broken windows may be taped but decayed boards remain untouched. Outdoor 'privies' are common and are usually in a state of disrepair, paper litters the streets, old cars or trucks are occasionally parked permanently on brick supports, and children play in the roadways. The volume of commercial traffic is high on many of these roads because of the proximity of the port, commercial areas and adjacent factories. The social and economic costs to the metropolis of these districts are matters for urgent and intensive study, for their influence is altogether disproportionate to their size.

Population Composition and Distribution

Ninety-eight percent of the residents of Metropolitan Auckland are of European origin. As the largest urban area in New Zealand, the city has drawn much of its population from rural districts and the towns of both islands. But European people have also come from other countries and alien languages and foreign accents are not uncommon in the streets. Of the non-European population in Auckland, Maori form the largest group, with Chinese second, in total numbers.[31] Auckland is also the main urban centre for Pacific Islanders resident in New Zealand.[32] In addition to these Islanders there are people of Indian and Syrian origin, West Indians and negroes. Thus with one resident in every eighty-six an alien and one in every fifty a Maori, the population of Metropolitan Auckland is the most mixed of the larger urban areas in New Zealand.

The pattern of distribution of the alien European population as a whole is influenced largely by the economic circumstances of individuals. The distribution of Maori and other non-European peoples in the metropolis, however, is the result of social factors in combination with economic conditions. The Maori and Pacific Islanders have tended to live together in communities and neighbourhoods within the older parts of the city and it is unfortunately true that they often have little choice but to accept residences in the decadent housing areas of Auckland.[33]

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[31] Although the 1160 Chinese residents of Auckland comprise the largest Chinese community in New Zealand, they form a smaller proportion of the total metropolitan population than in the Wellington urban area.

[32] Samoans formed sixty-eight percent of the islanders resident in Auckland in 1945. Altogether there were in the city six main groups of Polynesians, each of which probably exceeded 1000 by 1947.

[33] Because of the continuous drift of Maori rural dwellers to the city and the communal nature of Polynesian society, residential areas occupied by Maori people are often considerably overcrowded as well as blighted.

In marked contrast to the general concentration of Polynesian people is the dispersed distribution of Chinese throughout the numerous small retail areas and in the main business streets.[34] Three small nuclei of Chinese are found in the city core. Within the central area of Auckland, therefore, are appreciable neighbourhood communities of Maori, Pacific Islanders and Chinese. These districts of non-assimilated population, high density and decadent residences are the counterpart on a small scale of similar areas in the metropolitan centres of other countries.

The Character of Auckland

Among the urban areas of New Zealand, Auckland is distinguished primarily by its size. Several other features also characterise this metropolis. Metropolitan Auckland is a port; this has always been its prime function. In addition to its importance as a cargo port, Auckland is the main passenger centre for New Zealand with overseas termini for sea and air routes and rail and road connections. The importance of transport and the economic policy of the government have helped to produce the third major feature, the industrial nature of the metropolis. The city also acquires distinctiveness from its estuarine character, isthmus form, pleasant climate, volcanic cones and broad lava flows.

The life of Auckland centres around the Ligar Valley which is not only the focus of metropolitan transport but is also the major commercial, industrial, administrative and entertainment centre. Auckland is further distinguished by the radial-concentric distribution of different land-use areas around this common core and by the fact that in almost all land-use areas the influence of the past dominates the contemporary morphology. The relative importance of passenger and vehicular ferries also contributes to the individuality of the city.

The metropolis is the most cosmopolitan of all New Zealand urban areas; here, too, are the closest economic and social ties with the Pacific Islands. Residences of approximately equal value form homogeneous areas of appreciable size within the metropolitan limits. Blighted housing districts among these areas point to the lack of planning and the ills of rapid growth which distinguish the development of the city. Metropolitan Auckland is too youthful for all the buildings which were erected with non-permanent material during the first fifty years of European settlement to have been replaced; it is at the same time too old for the architectural styles of the colonial period to blend with the less ornate buildings of the present century.

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[34] Approximately fifty percent of the Chinese in Metropolitan Auckland live on their business premises within these areas. Included in this total are the eight percent who live in the city core in and adjacent to Grey's Avenue, Karangahape Road and Hobson Street. These concentrations delimit areas of employment as well as of residence; thus in Grey's Avenue are located two Chinese cafes, four Chinese grocers, and several gambling houses, all of which are relics from an earlier period.

The size of this city and the manner in which it has evolved have been responsible for many of the problems which exist today. No single problem is more pressing nor its solution more elusive than the task of limiting the future expansion of the metropolis and the size of the metropolitan population.

Two hundred years ago the Tamaki isthmus was the focal point for the Maori population of New Zealand. Then, as now, Tamaki was a transport centre, an area endowed with importance by its site characteristics and its location. Today the isthmus is again a major centre of New Zealand population. The relative importance of the site has declined, but from the location of the isthmus still comes the *raison d'être* of this metropolis. The wealth and stability of Auckland are derived not primarily from its factories and workshops, but from the warehouses and cool stores which serve the rich farm lands of the Auckland province. Metropolitan Auckland must continue to look to these areas rather than to protected local industries for its future sustenance.

THE APPLICATION OF THE CONCEPT OF POTENTIAL EVAPOTRANSPIRATION TO MOISTURE PROBLEMS IN NEW ZEALAND*

B. J. GARNIER

NEW ZEALAND is a land of great climatic contrasts. Despite its small area, its oceanic setting and its location in mid-latitudes, this 103,000 square miles of the earth's surface has a climatic variety which ranges from the ice caps of the Southern Alps, through cool, semiarid conditions in Central Otago, to the warm, superhumid climates of northern parts.[1]

These differences result mainly from the arrangement of the country's relief in relation to the direction of prevailing winds. The land lies between latitudes 34° 4′ S. and 47° 2′ S. and occupies an isolated position in the world's great water hemisphere. It is too small to have any major effect on the general circulation of the atmosphere in its vicinity, but locally major relief contrasts effectively interrupt the normal air flow to produce the country's remarkable diversity of climatic types.

One important feature of this diversity is that it is greatest below 2,500 feet of elevation. Above this height, climates are cool and superhumid, grading into cold at upper levels. Below this height, by contrast, are found not only cool and warm conditions, but moisture characteristics which vary from semiarid to superhumid. There are few permanent settlements above 2,500 feet and little farming is undertaken at such heights. The greater variety of climatic types, therefore, occurs on occupied land and a careful evaluation of their character is obviously important to a people who depend upon farming for their prosperity.

If the literature on the climate of New Zealand is examined it will be seen that the recognition of variety within the country has been largely confined to the variation of single elements, especially rainfall.[2] This attention has probably been given to precipitation partly because a greater number of stations and statistics exist for this element than for temperature, and partly because of the importance of different moisture conditions to regional contrasts within the country.[3] Effective moisture, however, does not necessarily vary as rainfall varies. For instance, summer is the season of maximum rainfall in the eastern part of the South Island[4] but the high temperatures of this period offset the increase in rainfall to such an extent that moisture effectiveness is lower at this time of year than at any other.

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*This paper is part of an investigation into the regional variety of climatic types in New Zealand which is being sponsored by a grant from the Research Grants Committee of the University of New Zealand, to whom grateful acknowledgement is made for assistance received.

[1] See B. J. Garnier, 'The Climates of New Zealand according to Thornthwaite's System of Classification', *Annals Assoc. Amer. Geogrs.*, Vol. 36, No. 3, 1946, pp. 151–177.

WATER NEED AS AN INDEX

The concept of the effectiveness of precipitation as opposed to the actual precipitation recorded in a rain gauge is not a new one in climatology. Many workers have tried to establish suitable relations between recorded precipitation and temperature so as to present a reliable index of effective moisture. One of the latest attempts is that of C. W. Thornthwaite[5] who presents the idea of water need, or potential evapotranspiration, considered in relation to the precipitation which actually occurs. This paper is an attempt to show how his proposals can help to elucidate moisture problems in New Zealand.

'Evapotranspiration' is the term given to the combined evaporation from the soil surface and transpiration from plants. It therefore represents the transport of moisture from the earth back again into the atmosphere. In other words, it is a reverse process to precipitation. The actual evapotranspiration which occurs over the earth's surface varies very much from place to place. It depends partly upon the climate and partly upon the amount and type of vegetation present. Where vegetation is sparse and climates are dry, evapotranspiration is a good deal less than it is in hot, wet areas carrying a close vegetative cover. However, the main reason for the lack of evapotranspiration in dry areas with a sparse plant cover is the absence of available moisture. If more moisture were present, then more vegetation would grow and evapotranspiration would increase correspondingly. It is apparent, therefore, that the actual evapotranspiration which occurs in various parts of the world is not always the same as would occur if moisture supplies were unlimited. This phenomenon, the evapotranspiration which would occur if moisture supplies were unlimited, is known as 'potential evapotranspiration'. The amount of potential evapotranspiration in any place is a variable which is dependent only on climate, especially heat and sunlight. Potential evapotranspiration is thus a function of temperature and length of day. Where days are long and temperatures are high, it increases to a maximum. Conversely it reaches a minimum under the influence of short days and low temperatures.

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[2] See especially the work of E. Kidson in the *New Zealand Journal of Science and Technology*, Vol. 12, 1931, p. 268 and p. 331; Vol. 13, 1931, p. 79; and Vol. 14, 1933, p. 220; and C. J Seelye: *ibid.*, Vol. 22, 1940, p. 183; and Vol. 27, 1946, p. 397.

[3] While this is true in general terms there are grounds for believing that effective temperature contrasts in New Zealand are underrated. It is hoped to report on some of these in a subsequent paper.

[4] E. Kidson: 'The Annual Variation of Rainfall in New Zealand', *N.Z. Journ. Sci. & Tech.*, Vol. 12, No. 5, 1931, pp. 268-271.

[5] C. W. Thornthwaite: 'An Approach toward a Rational Classification of Climate', *Geogr. Rev.*, Vol. 38, No. 1, 1948, pp. 55-94, and *idem:* 'Climate and Moisture Conservation', *Annals Assoc. Amer. Geogrs.*, Vol. 37, No. 2, 1947, pp. 87-100.

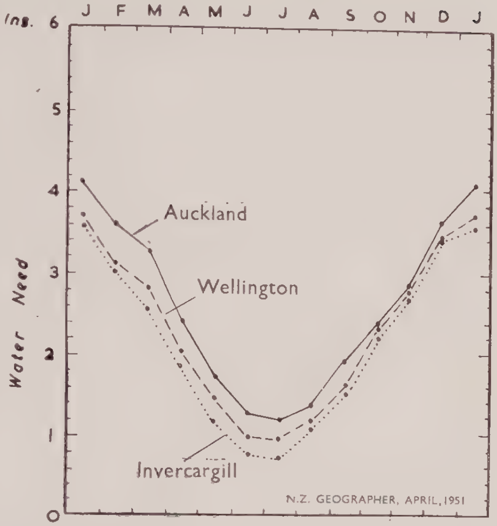

Fig. 1. Annual March of Potential Evapotranspiration at Three Coastal Stations.

CONTRASTS BETWEEN COAST AND INTERIOR

As a result of experimentation in the United States, Thornthwaite has devised formulas which can be used to compute the average monthly potential evapotranspiration of any place provided that mean monthly temperatures and the duration of daylight are known.[6] The value is measured in inches and in New Zealand varies from a maximum of 29.5 inches a year at Auckland to a minimum of not more than a few inches in the high, snow-clad Southern Alps. Potential evapotranspiration does not vary very much with latitude in New Zealand. At Wellington it is 26.2 inches a year and at Invercargill 24.8 inches. This gives an overall difference between coastal stations from north to south of only 4.7 inches.[7]

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[6] See Thornthwaite: 'An Approach toward a Rational Classification of Climate', *Geogr. Rev.*, Vol. 38, No. 1, 1948, pp. 55-94.

[7] Potential evapotranspiration does not increase north of Auckland. The figure for Te Paki, near Cape Maria van Diemen, is 28.7 inches.

It can be seen from the graphs (*Fig.* 1) that the annual march of potential evapotranspiration at coastal stations is very similar. This is especially true of those places open to predominantly westerly influences. At Auckland potential evapotranspiration varies from a maximum of 4.08 inches in January to a minimum of 1.19 inches in July. Corresponding figures for Wellington are 3.96 inches and 0.96 inches, and for Invercargill 3.58 inches and 0.74 inches. There is a tendency for east coast stations to show slightly greater extremes, although annual totals do not differ much. (See *Fig.* 2.)

Inland localities show greater extremes than coastal stations in the march of potential evapotranspiration through the year. Alexandra, for instance (*Fig.* 3), with a mean annual total of 25.6 inches, has a greater range of values than any other station in the country. In January potential evapotranspiration is 4.18 inches. This is greater than the January figure for any other station in New Zealand except Hastings (4.25 inches). The figure for July, on the other hand, is only 0.31 inches, a quantity which ranks low among New Zealand values in winter months. The tendency for the annual range of potential evapotranspiration to increase inland is shown by several interior stations and can even be discerned from statistics for stations only a few miles from the coast, as for example, Dunedin and Taieri aerodrome, six miles from Dunedin (*Fig.* 3). A similar contrast is shown between Napier and Hastings.[8]

DECREASE WITH ALTITUDE

The annual total of potential evapotranspiration decreases with altitude. At Hanmer (1225 feet) it is 24.51 inches, at Lake Tekapo (2350 feet) 22.95 inches, and at the Chateau Tongariro (3670 feet) it is 21.20 inches. It is interesting to note that midsummer figures are comparatively high even at these altitudes. At Hanmer, for instance, the value for January is 3.82 inches, at Lake Tekapo it is 3.84 inches, and at the Chateau Tongariro it is 3.25 inches. Midwinter figures, however, fall very low; at each of the stations just named the July value is less than half an inch.

Figures of potential evapotranspiration represent the monthly water need of plants; that is to say that for plants to flourish fully they must

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[8] The figures are:

Potential Evapotranspiration in Inches

	Jan.	July	Year	Range
Napier	4.15	0.91	28.55	3.14
Hastings	4.25	0.79	27.68	3.46

receive enough moisture to compensate for what will be lost through evaporation and transpiration. Thus, for the water need of plants to be satisfied precipitation must at least equal potential evapotranspiration. Where precipitation falls below this figure the climate is dry and moisture supplies are deficient; where it is above this figure the climate is wet and there is a surplus of moisture. By comparing the mean monthly precipitation of any place, therefore, with the mean monthly potential evapotranspiration or water need of that place, it is possible to obtain an idea of a climatic element of extreme significance to successful agriculture, for it gives us an indication of the amount by which the precipitation of a place is normally in excess of or less than what is required for successful plant growth.

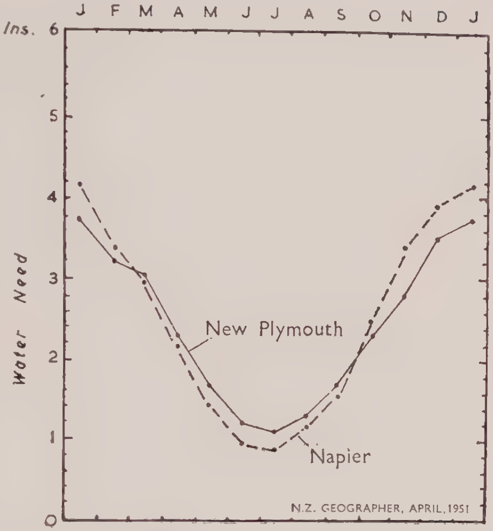

Fig. 2. Annual March of Potential Evapotranspiration, Coastal Stations, East and West Coasts, North Island.

Precipitation, however, is not a continuous process. It varies from day to day, from month to month, and from season to season. When precipitation does not occur plants draw upon the supplies of moisture stored in the soil. These moisture supplies are replenished periodically as rain falls, and provided it falls often enough and heavily enough they never

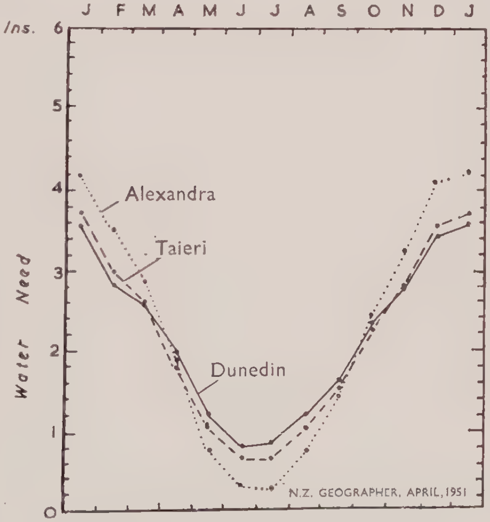

Fig. 3. Annual March of Potential Evapotranspiration, Dunedin and Inland Stations, Otago, South Island.

TABLE I

SAMPLE COMPUTATIONS TO OBTAIN MOISTURE DEFICIENCY OR SURPLUS

Sample Computation for Auckland*

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Precipitation	3.15	3.77	3.20	3.93	5.09	5.47	5.75	4.65	4.03	4.00	3.60	3.19	49.82
Potential Evapotranspiration	4.08	3.58	3.24	2.42	1.73	1.28	1.19	1.36	1.87	2.33	2.83	3.61	29.52
Precipitation less Potential Evapotranspiration	−0.93	0.19	−0.04	1.51	3.36	4.19	4.56	3.29	2.16	1.67	0.77	−0.42	20.30
Storage Change	−0.93	0.19	−0.04	1.30	0	0	0	0	0	0	0	−0.42	—
Storage	2.55	2.74	2.70	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	3.58	—
Moisture Deficiency	0	0	0	0	0	0	0	0	0	0	0	0	0
Moisture Surplus	0	0	0	0.21	3.36	4.19	4.56	3.29	2.16	1.67	0.77	0	20.21

Sample Computation for Christchurch*

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Mean Precipitation	2.20	1.81	1.96	1.84	2.88	2.54	2.66	2.05	2.01	1.86	1.80	2.49	26.10
Potential Evapotranspiration	3.90	3.25	2.75	1.88	1.17	0.74	0.72	0.96	1.53	2.35	2.98	3.73	26.06
Precipitation less Potential Evapotranspiration	−1.70	−1.44	−0.79	−0.04	1.71	1.80	1.94	1.09	0.48	−0.49	−1.18	−1.24	0.04
Storage Change	−1.09	0	0	0	1.71	1.80	0.49	0	0	−0.49	−1.18	−1.24	—
Storage	0	0	0	0	1.71	3.51	4.00	4.00	4.00	3.51	2.33	1.09	—
Moisture Deficiency	0.61	1.44	0.79	0.04	0	0	0	0	0	0	0	0	2.88
Moisture Surplus	0	0	0	0	0	0	1.45	1.09	0.48	0	0	0	3.02

*All computations are in inches.

become exhausted. It is important to remember, however, that the soil has not an unlimited capacity to store moisture. The actual capacity varies according to the type, structure and texture of the soil, but on the average soils are capable of storing an amount of moisture equivalent to about four inches of precipitation.[9] When the soil is fully charged with moisture any extra supply over and above that used by plants drains away as surface or underground runoff; when the stored moisture is used up a drought sets in.

In comparing water need with precipitation, therefore, it is necessary to take into consideration this four inches of stored moisture. If, for example, the water need of a given place in January is six inches and precipitation in that month is three inches, then three inches of stored moisture will be used up and only one inch of storage left for use in February. If in February precipitation is two inches less than water need then a deficiency of one inch will be recorded which will have to be replenished if the soil-moisture reservoir is to be recharged. This could take place in March if precipitation is sufficiently in excess of water need.

Balance of Water Need and Precipitation

The process of comparing water need with precipitation, therefore, is largely a kind of book-keeping in which an excess of precipitation over potential evapotranspiration is placed on the credit side of the account and a deficit of precipitation over potential evapotranspiration is placed on the debit side of the account whilst moisture stored in the soil is regarded as a kind of reserve fund. Sample computations for Auckland and Christchurch are given in Table I.

A comparison of the curves of monthly water need and mean monthly precipitation for four places in New Zealand is shown in Figure 4. The stations have been chosen because they illustrate the major kinds of relationships to be found. At Pahiatua, the precipitation in every month exceeds potential evapotranspiration. In midsummer precipitation and water need come very close together, but otherwise the monthly surplus is clear. Fairlie is a station illustrative of those parts of the country where precipitation is less than potential evapotranspiration in some months, but the total deficit does not normally amount to more than four inches. This means that in an average year the moisture stored in the soil during surplus months is not completely used up before recharge takes place. Thus, we can expect to find a threefold regime at Fairlie. From mid-June to October there is a surplus of moisture which totals 3.21 inches. From October to March, however, less precipitation occurs than is needed and the supplies of moisture in the soil are drawn upon to the extent of 3.78 inches. From March to mid-June precipitation is usually in excess of water need, but the excess cannot be regarded as surplus until the summer withdrawal of moisture from the soil has been made good. This does not normally occur until the middle of June.

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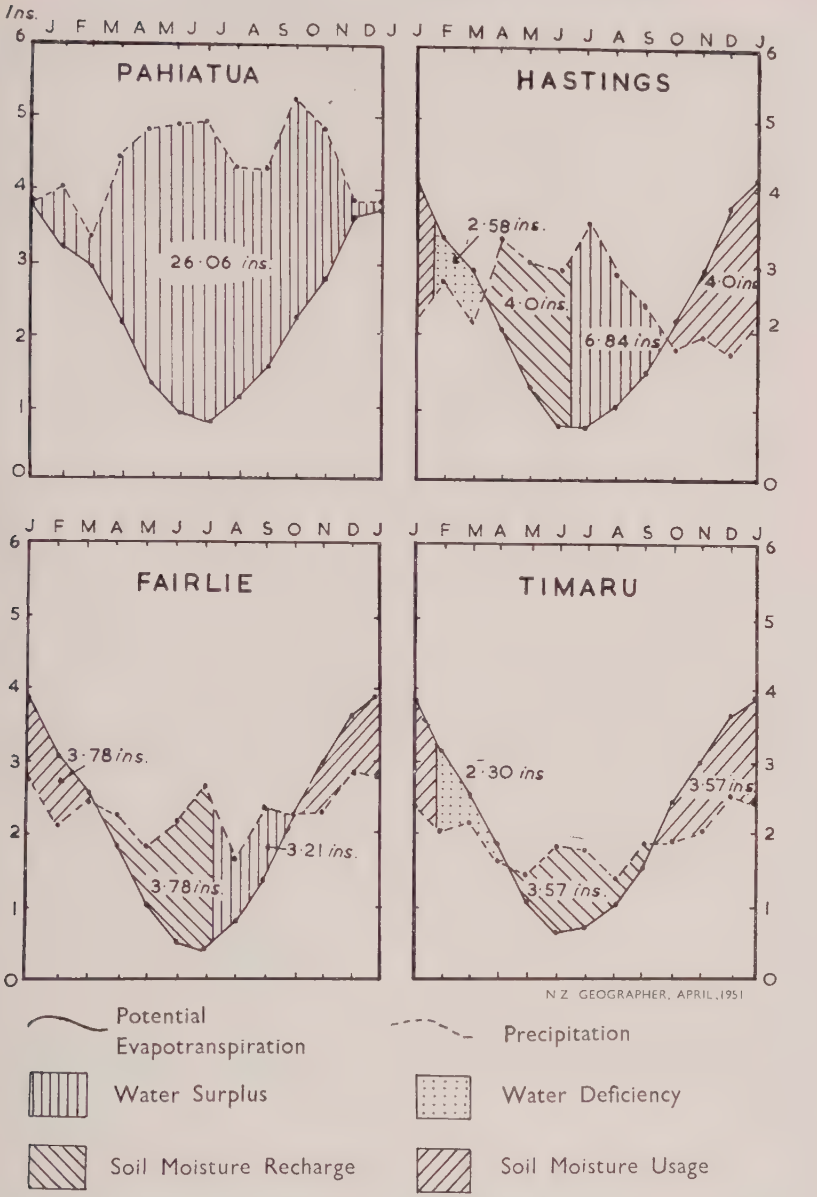
[9] Thornthwaite, *op. cit.*, p. 65.

The third example, Hastings, illustrates another regime found in New Zealand. This is one in which there are four periods, one of water surplus, one of deficiency, one of soil-moisture usage and one of soil-moisture recharge. In an average year at Hastings there is a surplus of moisture from early June to the end of September. From October to the middle of March precipitation is less than water need. So great is this deficit that by the middle of January the available soil moisture can be expected to have been used up and a season of moisture deficiency sets in which lasts to the middle of March. From then on precipitation is again in excess of potential evapotranspiration. However, it is not until early June that there is normally a surplus since the excess precipitation is being used to recharge the reservoir of soil moisture.

WATER DEFICIENCY IN CENTRAL OTAGO

In some parts of New Zealand the available precipitation is not usually equal to the task of supplying the annual water need. The extreme example of this is in semiarid Central Otago where only in the middle of winter, when potential evapotranspiration falls below half an inch a month, is precipitation sufficient to provide a small amount of soil-moisture storage. This amount, totalling just under one inch, is normally used up by the beginning of October, and from then to the end of April conditions of water deficiency can be expected. Outside Central Otago there are several areas where, although drought is not so extreme, it is not possible to rely on there being a period of water surplus. Such an example is shown in the graph for Timaru. Here there is an excess of precipitation over water need from mid-April to mid-September but it is not usually sufficient to create a surplus over and above the amount which can be stored in the soil. During the remainder of the year precipitation is less than water



N Z GEOGRAPHER, APRIL, 1951

Fig. 4. Curves of Potential Evapotranspiration and Precipitation at Four Stations in New Zealand.

need. The moisture which has been stored in the soil is, on the average, used up by mid-January, and a deficiency, totalling 2.30 inches, exists until the middle of April.

The foregoing discussion has directed attention to the possibility of using the concept of potential evapotranspiration as a means of discovering at what seasons of the year periods of moisture surplus or deficiency may be expected to occur and how great they are likely to be. It needs emphasising that the remarks which have been made concern average years; they are based upon mean values and give only a general indication of what is probable in different parts of the country. By applying the principles involved to individual years, however, it should not be impossible to obtain a measurement of the moisture situation at different places and at different times. Such a computation will be a useful means of combating the problem of drought—probably the farmer's greatest natural hazard.

Drought and Humid Regions

Drought is a relative term and hard to define precisely. Simply it can be taken to mean that there is insufficient moisture for the full development of plant growth. In the arid and semiarid parts of the world this is more or less a permanent condition and drought in these places is easily observed. Drought does occur, however, in humid regions. Here it is more difficult to recognise and harder to measure. It happens at different seasons and in different years. It occurs because rainfall is not adequately distributed through the year or because it does not come in sufficient quantities at the right time. Because the total annual rainfall of humid regions appears to give enough moisture for plant growth the problem of drought in these regions is not generally tackled adequately. Certainly, no permanent measures to combat a dry period are normally available and such preventatives as are used are usually taken on the spur of the moment to offset a particular situation. For this reason, a lack of rainfall in generally humid areas can often do great damage, while crop yields are often below the maximum simply because there is no adequate realisation of the extent to which a bad seasonal distribution of precipitation can impair production.

Since it is not possible to regulate the supply of rainfall to meet demands, the methods most commonly used to combat moisture deficiency are based upon supplying water by irrigation or upon farming methods designed to conserve moisture. Under the latter heading are such procedures as proper crop rotation to maintain a soil structure favourable to water holding, the use of fertiliser to the same end, seed selection to obtain varieties which are drought-resistant, and the planting of crops at seasons when the best use of water stored in the soil can be made.

The successful use of any of these methods depends upon an adequate knowledge of the seasons at which drought is likely to occur and upon the measurement of its intensity. In New Zealand, as has already been shown, it is only in Central Otago that conditions of more or less permanent drought prevail. Elsewhere drought is a seasonal problem, and the degree of its intensity varies from place to place and from year to year.

Application of the Concept

The concept of potential evapotranspiration has a twofold value as a means of combating drought. In the first place it can be used to ascertain when seasons of moisture deficiency may be expected and also how great the moisture deficiency is likely to be. For moisture deficiency cannot be defined solely in terms of inches of precipitation or of days without rain. It depends a great deal upon the rate at which moisture is being used up. Where it is being used up slowly a low rainfall will not necessarily produce conditions of drought. Where, on the other hand, evapotranspiration is high, more rainfall is required to offset the danger of drought. Once it is known how much rainfall is needed in a particular place then steps can be taken to offset the danger to crop production which will ensue if rainfall falls below this figure.

In the second place the concept of potential evapotranspiration can be used as a guide to how much extra moisture is required and when it should be applied. It is, therefore, a valuable tool for farmers in general and for the irrigation farmer in particular. To use irrigation properly requires considerable skill and knowledge. There is danger not only from under-irrigation but from over-irrigation as well. Over-irrigation produces waterlogging and sourness in the soil which can seriously impair soil fertility. On the other hand it is important not to provide crops with too little water or to wait until they wilt before irrigation is applied. It is necessary, therefore, to know when the supplies of moisture in the soil are approaching depletion. That is the time to irrigate; not after depletion has occurred, as a wilting plant reveals. An indication of this crucial point is given by knowing the water need of a given month and by relating that to the precipitation of that month, due allowance having been made for moisture stored in the soil.

Figure 5 is an attempt to show those parts of New Zealand which are moisture-deficient to a greater or lesser degree.[10] It is based upon average monthly values and therefore gives only a general indication of the distribution of moisture-deficient areas. It has been compiled by comparing figures of mean monthly potential evapotranspiration with those of mean monthly precipitation. It shows that the greater part of the country is without any significant moisture problem. In these areas (left unshaded on the map) precipitation normally exceeds water need in every month of the year or, if a deficiency does occur, it is too small to be noteworthy.[11] Practically all the North Island falls into this category and so does the greater part of the South Island. The remainder of the country has a moisture problem to a greater or lesser degree. It is notable that these problem areas, while not particularly significant on the basis of size, are regions of considerable importance to the national economy. Much of New Zealand's best farming land and chief crop areas are found in those parts of the country which have a moisture problem to some degree.[12] This makes it all the more necessary to inquire into the nature and extent of the deficiencies which do occur.

AREAS OF SLIGHT MOISTURE DEFCIENCY

These areas are those in which an appreciable amount of soil moisture is used up during the warmer months but in which the deficit of precipitation is normally not so great that an actual moisture deficiency occurs. The moisture problem is, therefore, not serious usually but in unfavourable years could cause difficulty. Within the class as a whole there is a general contrast between those parts having a long period of surplus and a season of soil-moisture usage in summer and early autumn, and those where the duration of surplus is more limited and the time of soil-moisture usage is extended over spring, summer and early autumn. This forms the basis of the grouping shown in Table II.

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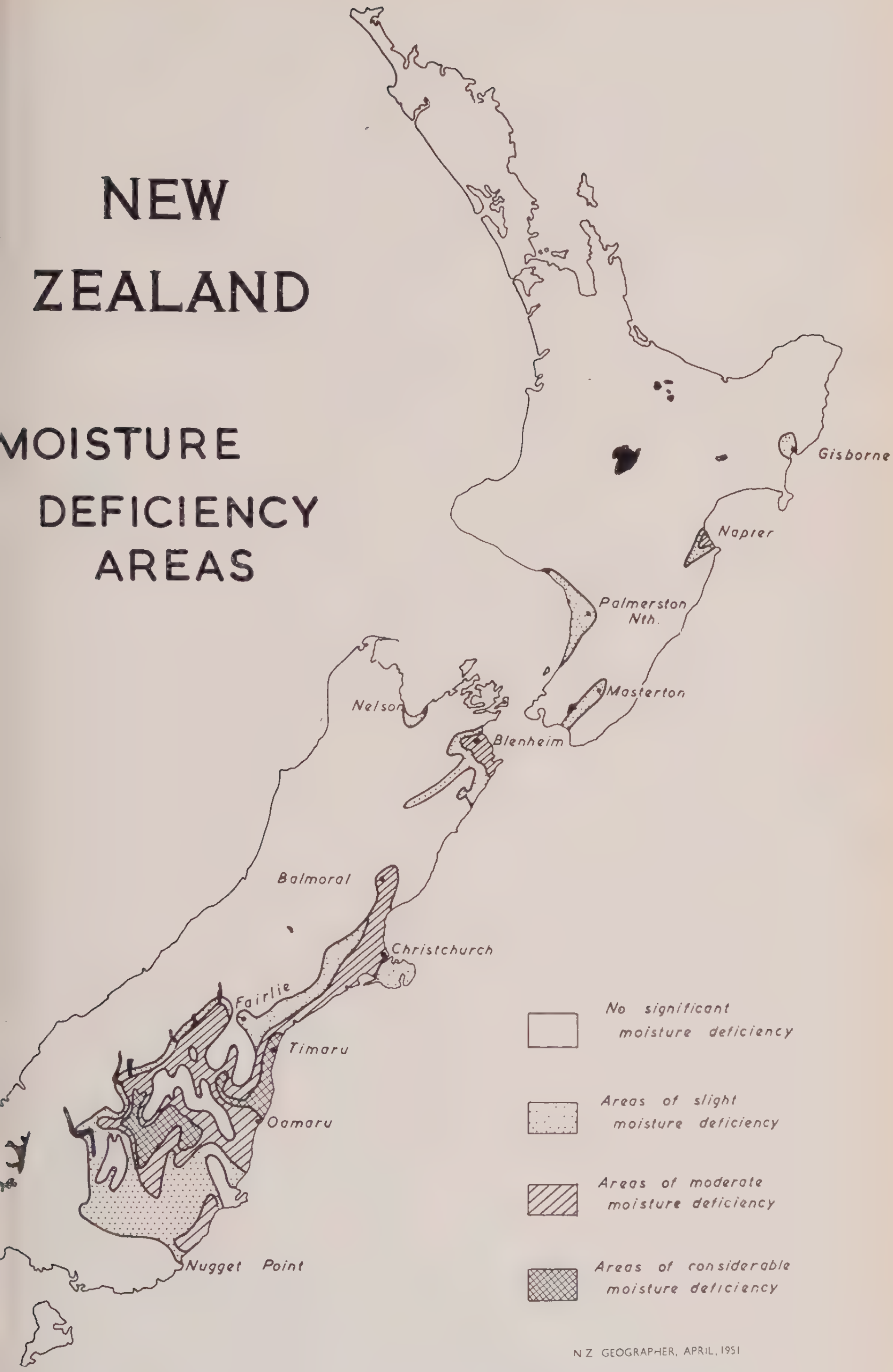
[10] The map has been compiled principally from the record of some sixty stations for which mean monthly temperature and rainfall statistics, derived from more than ten years' observations, are available. Additional information was obtained from statistics of rainfall from the many rainfall recording stations in the country. For an account of the development and present state of climatological observations in New Zealand the reader is referred to N. G. Robertson: 'The Organisation and Development of Weather Observations in New Zealand' in *New Zealand Weather and Climate*, a Special Publication of the New Zealand Geographical Society, Miscellaneous Series, No. 1, 1950.

[11] An example of the kind of deficiency which may occur in these parts comes from Hamilton. Here precipitation is less than water need in every month from December to March inclusive, but the monthly deficits are so small that the total lack amounts to only 0.73 inches.

[12] See K. B. Cumberland: 'The Agricultural Regions of New Zealand', *Geogr. Journ.*, Vol. 112, Nos. 1-3, 1948, pp. 43-63.



NEW ZEALAND
OISTURE DEFICIENCY AREAS
Gisborne
Napier
Palmerston Nth.
Masterton
Nelson
Blenheim
Balmoral
Christchurch
Fairlie
Timaru
Oamaru
Nugget Point
No significant moisture deficiency
Areas of slight moisture deficiency
Areas of moderate moisture deficiency
Areas of considerable moisture deficiency
N Z GEOGRAPHER, APRIL, 1951

Fig. 5. Areas of Moisture Deficiency in New Zealand.

TABLE II

Stations in Areas of Slight Moisture Deficiency

Seasonal Precipitation Requirements*

Station	Season of Water Surplus				Season of Soil-Moisture Usage				Season of Soil-Moisture Storage			
	Months	Water Need	Pptn. Required	Pptn. Received	Months	Water Need	Pptn.† Required	Pptn. Received	Months	Water Need	Pptn.‡ Required	Pptn. Received
Group (a)												
Gisborne	May-Oct.	8.54	8.54	24.60	Nov.-Jan.	10.98	6.98	7.79	Feb.-April	8.59	11.78	11.72
Wanganui	June-Nov.	9.87	9.87	18.35	Dec.-Mar.	13.52	9.52	10.85	April-May	3.62	6.29	6.47
Masterton	June-Oct.	6.66	6.66	18.37	Nov.-Mar.	16.33	12.33	12.41	April-May	3.26	7.18	6.91
Nelson	June-Nov.	9.64	9.64	20.10	Dec.-Mar.	13.87	9.87	11.56	April-May	3.51	6.42	6.33
Queenstown	July-Oct.	4.94	4.94	9.72	Nov.-Mar.	16.55	12.55	12.67	April-June	3.40	7.28	7.92
Group (b)												
Ashburton	July-Sept.	3.00	3.00	7.44	Oct.-Mar.	18.56	14.56	14.97	April-June	3.59	7.18	7.26
Fairlie	July-Sept.	2.52	2.52	6.63	Oct.-Mar.	18.52	14.52	14.74	April-June	3.31	7.09	6.19
Taieri Aero.	July-Sept.	3.28	3.28	6.15	Oct.-Mar.	17.78	13.78	14.47	April-June	3.63	7.04	6.93

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*All measurements are in inches.

†Precipitation required in this season in order to prevent a moisture deficiency equals water need less four inches.

‡This column refers to the precipitation required to recharge fully the soil-moisture reservoir having regard to the amount of that reservoir's normal depletion during the season of soil-moisture usage.

At Wanganui there is a water surplus from June to November. The water need during this time is 9.87 inches. This figure, therefore, represents the minimum precipitation requirement during this period in order to make sure of the soil moisture storage necessary for summer use. During December, January, February and March precipitation is normally less than water need and soil-moisture reserves have to be called upon by plants. The extent of the deficit is not usually more than three inches but soil-moisture reserves will be completely used up and a deficiency created unless precipitation totals 9.52 inches or more in these months. Provided that the required total is reached, however, no deficiency will occur. If it is not attained then a rainfall above the 6.29 inches normally required during the period of recharge is necessary or else the period of recharge will be prolonged into winter months.

Wanganui is a station typical of conditions in Group (a). In Group (b) the period of surplus is shorter than in Group (a) and there is a longer period of soil-moisture usage. This usually occurs from October to March inclusive, that is, during spring, summer and the first month of autumn. In spite of the duration of the time in which soil-moisture reserves are being drawn upon, no actual deficiency can be expected as the total deficit of precipitation over water need is usually under four inches, although it can be expected to approach this value closely. For instance, at Fairlie 3.78 inches of soil moisture are used and at Ashburton 3.59 inches. This situation suggests that the likelihood of deficiencies in summer months is greater in these parts than in those areas covered by the stations in Group (a).

The regime at Ashburton indicates the general course of the soil-moisture situation in Group (a). Here the period of surplus is from uly to September during which time water need amounts to three nches. From October to March, soil-moisture reserves are being used by vegetation. The potential evapotranspiration in this period s 18.56 inches so that precipitation at this time must total at least 14.56 inches, otherwise a deficiency will occur. Soil moisture recharge s comparatively rapid. It occurs in the three months April, May and une and is likely to be achieved when precipitation after the end of March has reached a total of 7.59 inches.

AREAS OF MODERATE MOISTURE DEFICIENCY

In this group are found those stations in which a winter surplus and a summer deficiency occur (Table III). These parts, therefore,

TABLE III

STATIONS IN AREAS OF MODERATE MOISTURE DEFICIENCY

Seasonal Precipitation Requirements*

Station		Season of Moisture Surplus				Season of Soil-Moisture Usage			
		Months	Water Need	Pptn. Required	Pptn. Received	Months	Water Need	Pptn. Required	Pptn. Received
North Island:	Napier	July-Sept.	3.66	3.66	8.74	Oct.-Dec.	9.75	5.75	6.15
	Hastings	July-Sept.	3.36	3.36	9.13	Oct.-Dec.	9.09	5.09	5.85
South Island:	Blenheim	Aug.-Sept.	2.56	2.56	4.45	Oct.-Dec.	9.15	5.15	5.72
	Balmoral	Aug.-Oct.	4.54	4.54	6.95	Nov.-Feb.	13.73	9.73	9.48
	Christchurch	July-Sept.	3.21	3.21	6.72	Oct.-Jan.	12.96	8.96	8.35
	Lake Tekapo	July-Sept.	1.96	1.96	3.40	Oct.-Jan.	12.14	8.14	7.95

Station		Season of Moisture Deficiency				Season of Soil-Moisture Storage			
		Months	Water Need	Pptn. Required	Pptn. Received	Months	Water Need	Pptn. Required	Pptn. Received
North Island:	Napier	Jan.-March	11.55	11.55	8.19	April-June	4.60	8.60	9.19
	Hastings	Jan.-March	10.68	10.68	7.34	April-June	4.45	8.45	9.52
South Island:	Blenheim	Jan.-April	12.56	12.56	7.05	May-July	2.57	6.57	7.42
	Balmoral	March	2.83	2.83	1.91	April-July	4.16	8.16	8.30
	Christchurch	Feb.-April	7.88	7.88	5.61	May-June	1.91	5.91	5.42
	Lake Tekapo	Feb.-March	5.78	5.78	3.02	April-June	3.07	7.07	6.20

All measurements are in inches.

can normally expect to have a period in which soil-moisture reserves are entirely used up and crops must depend solely on current rainfall at a time when water need is high.

The North Island location of this class is confined to the vicinity of Napier and Hastings. Here there is a surplus of water for three months in winter and a deficiency for three months in summer. This deficiency can be overcome only if the precipitation from January to March is over 11.55 inches in the case of Napier and 10.68 inches in the case of Hastings, since these figures represent the potential evapotranspiration during the deficiency periods.

Blenheim Distinctive

In the South Island it is necessary to distinguish between the moisture regime at Blenheim and that in the rest of the area falling within this category. At Blenheim there is a short period of surplus in August and September. This is followed by a time of soil-moisture usage. By the end of December the moisture reserve is normally used up and a deficiency occurs which lasts until April. Over twelve inches of rain are required after the end of December before the period of moisture recharge begins. This usually starts in May and lasts until 6.57 inches have been recorded, by which time the reservoir of soil moisture will have been refilled.

Further south a generally similar regime exists on the lowlands of north and mid-Canterbury and in the Mackenzie Basin. Here the period of deficiency is shorter and of surplus longer than at Blenheim. At Christchurch, for example, a surplus occurs from July to September and a deficiency from February to April. During the latter period water need is nearly eight inches. Precipitation begins to satisfy moisture requirements in May and there is a rapid recovery of soil moisture, for, after 5.91 inches have fallen—usually by the end of June—the moisture reservoir of the soil has been fully recharged. Precipitation remains in excess of water need until the end of September. From then on, soil-moisture reserves are utilised and, provided a total of 8.96 inches of rainfall is recorded from October to January, will last until the beginning of the new year.

Areas in this group can be regarded as those in which successful agriculture needs to recognise the probability of droughts each summer with occasional periods of severe moisture shortage. These problems can be met by means of seed and stock selection, water-conservation

TABLE IV

STATIONS IN AREAS OF CONSIDERABLE MOISTURE DEFICIENCY

Seasonal Precipitation Requirements*

Station	Season of Soil-Moisture Usage				Season of Moisture Deficiency				Season of Soil-Moisture Storage			
	Months	Water Need	Pptn.† Required	Pptn. Received	Months	Water Need	Pptn. Required	Pptn. Received	Months	Water Need	Pptn.‡ Required	Pptn. Received
Timaru	Oct.-Jan.	12.81	9.30	8.82	Feb.-April	7.64	7.64	5.82	May-Sept.	4.81	8.81	8.32
Waimate..........	Oct.-Feb.	15.66	11.66	11.77	Mar.-April	4.69	4.69	3.91	May-Sept.	5.23	9.23	9.30
Alexandra........	Aug.-Sept.	2.20	1.25	1.43	Oct.-April	19.54	19.54	9.27	May-July	1.46	5.46	2.41

*All measurements are in inches.

†The figure in this column is the amount required in this period if the soil moisture normally stored in the soil during the period of soil-moisture storage is to last to the end of the period of soil-moisture usage shown for each station.

‡This figure represents the amount of precipitation required to charge the soil-moisture reservoir to its full capacity of four inches.

farming methods, careful choice of planting times in relation to growth requirements and available moisture, and irrigation.

Areas of Considerable Moisture Deficiency

Stations in these areas lie in those parts of the country in which at no season does a period of moisture surplus normally occur. The driest part of the area is in Central Otago where the figures for Alexandra (Table IV) show how far short of water need precipitation falls. Here the problem of drought is a continuing one and successful cropping or stock rearing requires irrigation and other special techniques.

Conditions of moisture deficiency are less severe in the vicinity of Waimate and Timaru. At the latter station, the period of deficiency does not normally set in until February and at Waimate until March. Provided a normal winter's rainfall is experienced, therefore, the early planting of crops could be undertaken to take advantage of soil moisture if irrigation facilities are not available. The area is one which is highly susceptible to drought, however, and farmers should have means readily at hand for combating such situations.

A general feature of all the areas of New Zealand in which moisture-deficiency problems are liable to occur is that the climate varies considerably from year to year. Seelye has drawn attention to the average variability of precipitation in New Zealand.[13] His paper shows that the areas of greatest expected precipitation variability coincide closely with the regions of probable moisture problems which this paper has established. The variability is of the order of fourteen percent or more, which is considerable in view of the generally low annual precipitation totals involved. This makes it all the more important to have some standard of reference as to the amount of rainfall which actually constitutes a deficiency or surplus in any particular season. This is possible by means of the concept of potential evapotranspiration.[14] Even if the results achieved are, for the time being, somewhat general they do at least provide a basis upon which to judge the significance of monthly precipitation values and they may well suggest fruitful lines of further inquiry.

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[13] C. J. Seelye: 'The Variability of Annual Rainfall in New Zealand', *N.Z. Journ. of Sci. & Tech.*, Vol. 22, 1940-41, No. 1b, pp. 18b-21b.

[14] Potential evapotranspiration probably varies slightly from year to year as temperatures vary. The variation is not so great as that of precipitation and is unlikely to make much alteration to the general picture. It is nevertheless worthy of investigation.

FAULT VALLEYS AND SHUTTER RIDGES AT WELLINGTON

C. A. COTTON

THE PRESENCE of a fault cicatrice, associated with shutter ridges that indicate an important transcurrent (strike-slip) component of displacement, shows that there has been recent activity on the southwestern part of the line of the Wellington fault. It is probable, therefore, that valleys on this line are fault valleys rather than fault-line valleys.

The relatively modern displacement on the Wellington fault, which has made it the northwestern boundary of Port Nicholson and the Hutt Valley, is aligned on a shatter belt that extends southwestwards across the Wellington Peninsula and is conspicuously revealed in roadside cuttings in the Wellington suburbs of Kelburn and Northland. The line of the fault, and of the presumably more ancient fault zone guiding it, cuts across the more nearly meridional grain of the country. This latter is attributable in part to erosional adjustment to folded structure and belts of strike faulting in the Mesozoic greywacke terrain, and in part probably to more modern faulting which has followed old lines.

VALLEY ALIGNMENT ON THE WELLINGTON FAULT

Along the southwestern part of the Wellington fault there is a very striking and continuous furrow (*Fig.* 1). This is not, however, the consequent fault-guided valley of a single stream, but is followed in one part by the headwater reach of the Kaiwarra (freshly captured by the Kaiwarra from the Karori system) and farther on to the southwest by one and then another headwater branch of the Silver Stream, a tributary of the Karori which follows a very roundabout course (*Fig.* 2). If the captured head of a Karori branch which has become the upper Kaiwarra be restored to the Karori system, the pattern of the three streams, all Karori branches, aligned on the fault is seen to be remarkable.

The head of the Kaiwarra was apparently annexed from the Karori system and not from a former northward-flowing river, as earlier suggested.[1] Whether the upper Karori has itself been diverted from a former northward outlet is another question. A further suggestion that the roundabout course of the Silver Stream is due to diversion of its headwaters into the Karori system by piracy[2] seems inconsistent with a hypothesis presently to be developed that the valleys on the Wellington fault line are of recent origin. This theory may also, therefore, be tentatively abandoned.

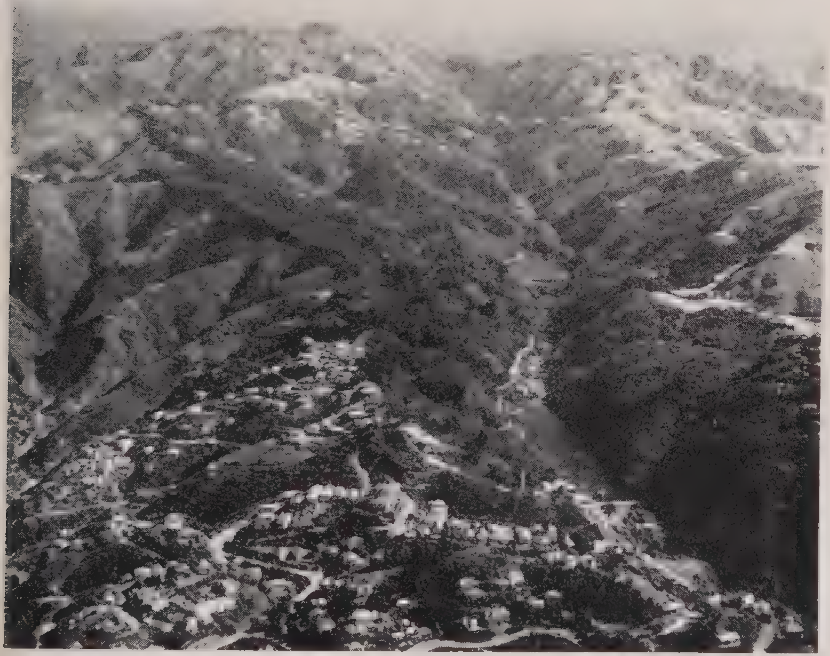

Fig. 1. View southwestwards along the Upper Kaiwarra and Silver Stream Valleys. These valleys lie along the line of the Wellington fault. (*Photograph by the Department of Geography, Victoria University College, Wellington.*)

FAULT OR FAULT-LINE VALLEYS?

The V form of the valleys on the fault line, though rather pronounced, is not a symmetrical V. The northwest walls, which discontinuously extend southwestwards the line of the Wellington fault scarp seen in the harbourside cliffs, are distinctly the steeper side of the furrow, though their fault-scarp-like appearance is somewhat masked by the fact that altitudes are similar on each side of the valleys. An alternative explanation that the scarp at the fault line is a 'fault-line' scarp exposed by active selective erosion on a shatter belt, or zone crushed and weakened by distributed faulting, has been offered,[3] but its correctness, at least as a complete explanation, is very doubtful. Along the line there is a cicatrice of active faulting which is clearly discernible from the air and which shows up unmistakably in vertical photographs (*Fig.* 3). The presence of this indicates some very recent emergence of the fault surface, as well as effects of transcurrent displacement. In view of these signs of activity the furrow along the fault line must be described as either a fault-angle tectonic landscape form or some combination of a fault-angle valley with one produced by erosion which has gone on contemporaneously with displacement in the fault zone.[4] Now that the whole feature is known to be closely

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[1] C. A. Cotton: 'Notes on Wellington Physiography', *Trans. & Proc. N.Z. Inst.*, Vol. 44, 1912, pp. 245-265; 'Recent and Subrecent Movements of Uplift and Subsidence near Wellington, New Zealand', *Scot. Geogr. Mag.*, Vol. 28, 1912, pp. 306-312.

[2] C. A. Cotton: 'Fault Coasts in New Zealand', *Geogr. Rev.*, Vol. 1, 1916, pp. 20-47.

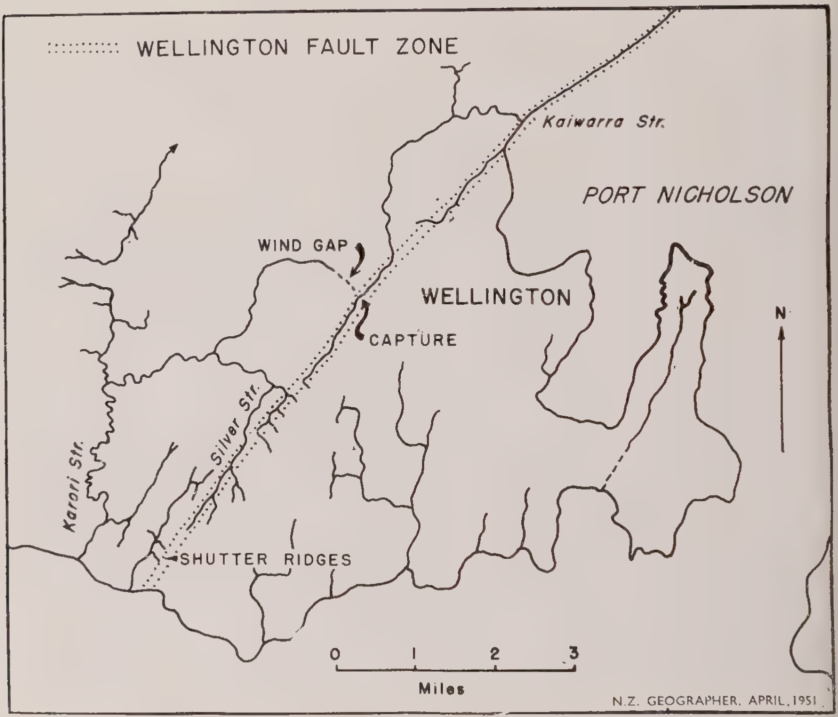

Fig. 2. The Karori Valley System and the Southwestern Part of the Wellington Fault.

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[3] C. A. Cotton: 'Supplementary Notes on Wellington Physiography', *Trans. & Proc. N.Z. Inst.*, Vol. 46, 1914, pp. 294-298.

[4] C. A. Cotton: 'Tectonic Scarps and Fault Valleys', *Bull. Geol. Soc. Am.*, Vol. 61, 1950, pp. 717-758. Refer to p. 751.

related to active faulting, it is impossible to have faith any longer in a hypothesis of its ancient, two-cycle origin, such as is implied in the suggestion that a through stream once followed this line, flowing

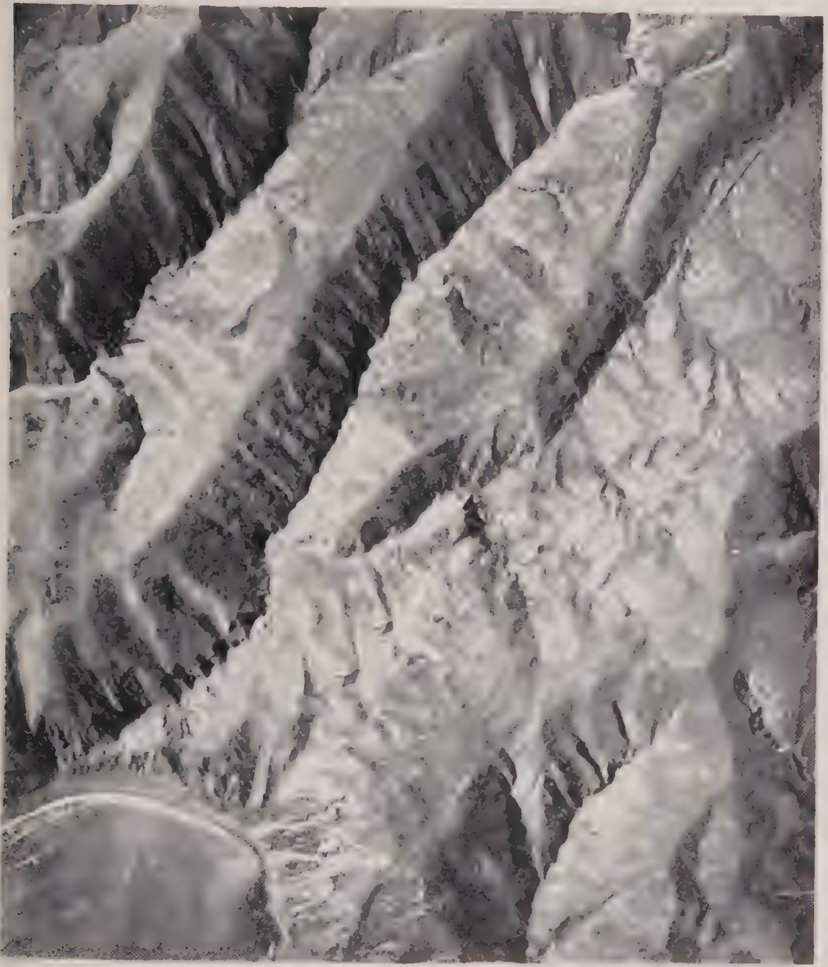

Photo: Department of Lands and Survey

ig. 3. Indications of Recent Activity at the Southwestern End of the Wellington Fault: S—Shutter Ridges; O—Fault Cicatrice in the Valley of the Silver Stream.
(Approximate scale 1:23,000. North at the top.)

t a higher level on a land surface which has since been destroyed by rosion. A notch at a point where there is now a divide in the furrow parating the head of the Kaiwarra from the elbow of the Silver tream might find an explanation in a through-stream hypothesis; ut its high altitude seems rather to imply that the collinear valleys aking the segmented furrow are really of independent origin.

In the two southwesterly segments occupied by branches of the Silver Stream the scarplet or cicatrice indicative of active faulting is conspicuous near the axis of the furrow (*Fig.* 3, northeast corner), and it is still more so southwestwards beyond the divide at the head of this valley system, where the outcrop of the fault continues over a westward-sloping surface with seaward drainage. In the upper valley of the Silver Stream displacements in the later episodes of activity have produced a rejuvenating scarplet which has added to the height of the northwest valley wall. For the most part this hugs and oversteepens the base of the valleyside scarp, close to which the stream also flows; but at one place the cicatrice crosses the stream, and here (O in *Fig.* 3) offsetting of a tributary watercourse takes place to the extent of about three chains (sixty metres). This indicates a dextral transcurrent displacement, the amplitude of which greatly exceeds that of the scarp-making (dip-slip) component accompanying it. There is no evidence as yet on record of similar transcurrent movement on the northeasterly extension of the fault along the shore of Port Nicholson and up the Hutt Valley fault-angle depression.

Near its southwestern end, where it skirts a westward-sloping land surface, the fault trace crosses spurs in such a way that the transcurrent component of movement has made shutter ridges (S in *Fig.* 3; and *Fig.* 4). These ridges block the gullies and show that here also the amplitude of the displacement has been about three chains. It is scarcely probable that the whole of this took place in a single jolt; more probably intermittent movement continued over a period of many centuries.

Date of Activity

The date of this displacement may very well have been as ancient as the latest rejuvenation of the fault scarp along the shore of the harbour. This presumably accompanied the latest episode only of the down-warping or 'basining' of Port Nicholson. That the lateral movement which made the shutter-ridge pattern was not extremely recent is shown by fading (erosional obliteration) of some parts of the fault cicatrice. Clearly also the offset of the shoreline at the end of the fault trace has been much rounded off by very vigorous marine erosion (*Fig.* 3). The height of the sea cliffs—about 1000 feet—has necessitated the breaking down and removal of a vast quantity of rather hard greywacke to allow of this. Such an operation

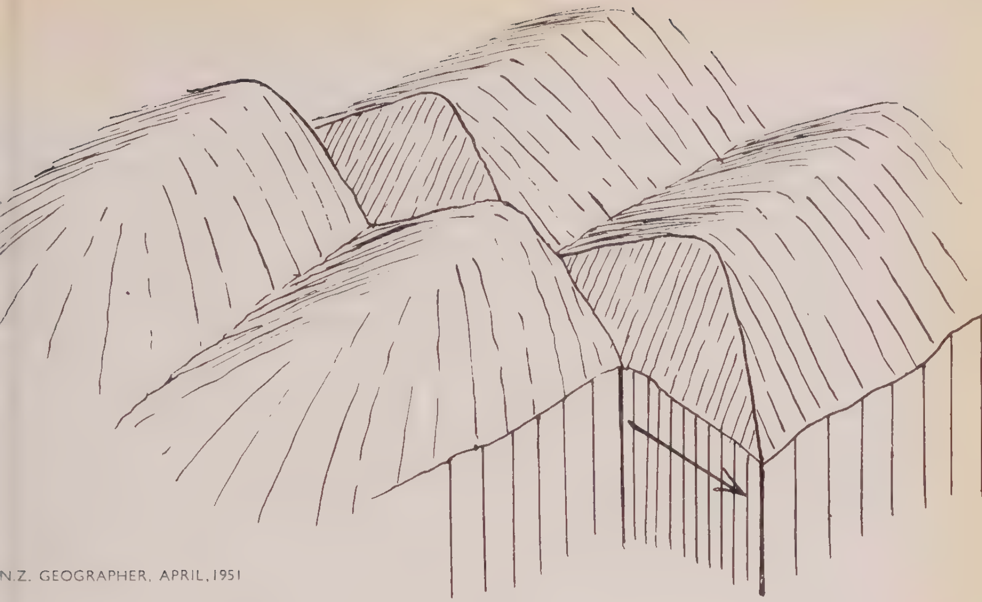
N.Z. GEOGRAPHER, APRIL, 1951

Fig. 4. Block Diagram of Shutter Ridges. These have been made by dextral transcurrent movement on an active fault.

might require more than a thousand years; but the latest movement on the fault may nevertheless have taken place fairly recently if the displacement has been intermittent.

Earlier Transcurrent Movement

Earlier movement of much greater amplitude than that indicated by displacement of the shutter-ridge spur-ends is strongly suggested by the pattern formed by tributary streamlets and interstream spurs on the southeastern side of the fault line in the segments of the furrow occupied by the Silver Stream and the upper Kaiwarra. These trail conspicuously in the dextral direction—i.e. they come in from south instead of southeast—contrasting with those on the other side, which join the main stream more nearly at right angles. This trailing probably results from the integration of many small offsets caused by intermittent transcurrent movement spread over a zone of distributed faulting.[5] Contemporary erosion during the faulting may have contributed to the shaping of the furrow as a whole, the gradual development of which may have taken a hundred times as long as the shifting of the surviving shutter ridges.

Possible Fault Control of Adjacent Valleys

Two short southward-draining valleys west of the fault trace (*Fig.* 3) are aligned parallel to it and are thus differentiated from the more nearly meridional features common in this district. It may be suspected that these valleys have originated on short parallel faults related in some way to the Wellington fault; but they may have been rapidly developed by headward erosion on such lines as fault-line valleys. They are without traces of active faulting in their axes and have not the asymmetric form of fault-angle valleys. Moreover, their tributaries do not trail in the manner described above. A reminder of the rapidity of some fault-line erosional development is afforded by the headward extension of a ravine burrowing into the coastal cliff along the shatter belt at the southwest end of the Wellington fault line (*Fig.* 3). Future headward development of this ravine may perhaps reverse the flow of the Silver Stream.

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[5] *loc. cit., Fig.* 24.

THE UTILISATION OF EXOTIC FORESTS IN NEW ZEALAND

CLIVE TIDMARSH

TIMBER has always been important in New Zealand economy right back to the days of Captain Cook and later when the early whalers and traders felled young kauri for spars around the bays and coves of Northland. And when New Zealanders think of their timber wealth they invariably think in terms of the lovely and useful native woods—kauri, rimu, matai, totara and the rest. But within a hundred years, by prodigal use of fire and axe, the native forests have been reduced from over 27.5 million acres to less than twelve million and kauri and kahikatea have been almost eliminated from commercial use.

Yet New Zealanders have not alone been noted for their past indifference to the natural forest wealth. Apart from some European countries such as France and Germany the growth of a forestry conscience has been slow. The British peoples, in particular, have worried little about forests until some calamity caused by forest destruction, such as floods or erosion, or a serious shortage of timber, has forced them to action. Destruction of the forests, with belated recognition of the need for replanting and management, has been a cardinal sin in every timber-producing country of the world. For centuries Man, the destroyer, has been extremely active. Within 500 years he has destroyed at least two-fifths of the original forest. Behind that there lies a tragic story of soil exhaustion, erosion, floods and a colossal waste of human life and endeavour.

In this young country forest and soil conservation, as a matter of national policy, has come to the fore only within the last few decades. It is indeed fortunate that today, in the middle of the twentieth century, timber and wood-product needs do not depend on the dwindling resources of indigenous forests. To supplement them are millions of exotic pine trees, mainly covering the pumice lands on the central plateau of the North Island, and these forests now represent a new-found wealth to the dominion. Within thirty years the squandered native stands have been replaced.

It was in the early twenties of the present century that the New Zealand Forest Service first seriously encouraged the planting of thousands of acres of pines, although planting had already been undertaken at Whakarewarewa, Waiotapu and Kaingaroa between 1900 and 1910. These exotic conifers grow faster and flourish better in this country than in their native habitat. Of the many species planted the most common is *Pinus radiata,* generally called insignis pine. About eighty percent of the private commercial softwood forests comprise this species, with smaller stands of *P. ponderosa, P. pinaster, P. murrayana, P. laricio* and *Pseudotsuga taxifolia* (Douglas fir).

SIGNS OF THE TIMES

In 1924 Sir R. Heaton Rhodes, then Commissioner of State Forests, stated in an introduction to an official brochure:

> A world-wide timber famine, with its attendant high prices, is threatened and how are we to compensate for the loss of external supplies and the diminishing supplies of native timbers? The complete destruction of the original forests in many districts, together with the decrease in available milling areas, has brought about a condition of things which has made timber both dear and scarce, and it is not unreasonable to suppose that timber prices will never fall, but on the contrary, will be higher than at present as supplies become exhausted. For this there is only one rememdy—grow your own timber or pay somebody else their price to grow it for you.[1]

That statement expressed the common opinion of the day and it was in this atmosphere that the earliest of the afforestation companies was promoted. From the early 'twenties to the middle 'thirties some 372,000 acres of private forests were planted, with the state contributing a further 447,000 acres. By 1934 millions of pine trees were approaching maturity, but no provision had been made to convert them into useful products. Little was known twenty-five years ago about the use and marketing of insignis pine, which was generally regarded as a low-grade timber. Critics freely predicted that investors who had bought forestry bonds could expect little, if any, return from their outlay. But the vision, confidence and ability of those who pioneered the first utilisation industries have been well rewarded. As yet only the fringe has been touched in complete utilisation, but a most promising beginning has been made. Planned planting and efficient silvicultural practices have come into their own, but to cope with the tremendous potential of the forests now maturing calls for boldness, hard thinking and hard toil. No unbiassed observer would maintain that these qualities have not been displayed to the full so far as the private exploitation of the forests is concerned.

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[1] *Tree Planters Guide,* Wellington, 1924, p. 3.

The exotic forests may be divided into two broad belts in the centre of the North Island on the Volcanic Plateau. South and east of Rotorua are some 350,000 acres of government-owned forests, forty-three percent of which are made up of *Pinus radiata.* Further to the west, bounded by the Waikato River and stretching roughly between Putaruru and Taupo, lie some 176,000 planted acres of N.Z. Forest Products Ltd., the largest of private owners and the largest wood-utilisation enterprise in the southern hemisphere. Smaller in area (60,000 acres) but well advanced on the road to fuller utilisation are the stands of Whakatane Board Mills Ltd. situated mainly some fifteen miles inland from the mouth of the Whakatane River.

Rapid Growth and Regeneration

Two features of New Zealand's exotic forests which make them preeminent are, firstly, the astonishing rate of growth, and secondly, the ability of the trees to regenerate themselves. With very little forest management, apart from protection from fire, *Pinus radiata* will grow to a height of 120 feet in about twenty years, with a diameter at the butt of up to fifteen inches. Growth over the total area is at the rate of about 10,000 tons, or five million board feet, of timber a day. Natural regeneration takes place, even over areas ravaged by fire, at sometimes up to sixty percent of original plantings. While pruning and thinning have been practised in some of the government stands, the general policy with the private companies has been to cut only healthy trees which can be economically extracted. Indicative of the enormous resources is the fact that only slightly over 5000 acres of N.Z. Forest Products' plantations of 176,000 acres had been cut over up to 1949. Full utilisation of all exotic forests in the dominion would involve an annual cut of probably 30,000 acres, and would necessitate the establishment of new integrated industries involving capital expenditure of perhaps £50,000,000 for factories and plant and the employment of between 20,000 and 25,000 persons.

With the depletion in native timber supplies and the continued intense demand for building materials, utilisation is being expedited more than ever before. The urgent necessity for this was underlined by the Director of Forestry when he stated: 'The sawmilling industry is most keenly affected, and the implications of the policy of rationing indigenous timber need to be appreciated, for mills will, in increasing numbers, cut out, and find they have no option but to cease business or switch their operations to the exotic forests.'[2] Thus both the government, with two main mills at Rotorua and at Kaingaroa, and the private companies are straining every effort to increase production of sawn timber. But as important, if not more so, than output of building lumber is the trend towards more complete integration of the forest industries, including the utilisation of waste. Already this has led to the establishment of pulp and paper mills, with ancillary industries utilising the raw material, and may yet lead to manufacturing of such much-sought commodities as rayon, 'wet-strength' paper, printing and writing papers, cellulose and newsprint. Successful and efficient production of cardboard and paperboard is carried on by Whakatane Board Mills Ltd., the local pulp being blended with imported chemical pulp. This company has also extended its operations to sawmilling.

On a mammoth scale for New Zealand, however, is the £4,500,000 expansion programme of N.Z. Forest Products Ltd., now well advanced. This involves additional sawmills to cut up to seventy million board feet a year, a kraft-pulp mill to manufacture up to 30,000 tons a year, a kraft-paper mill making some 20,000 tons of paper a year, and a fibre container factory. In addition extensions have been made, and more are planned, to plant manufacturing wallboard, hardboard and multiwall paper bags now made temporarily with imported kraft paper.

PARALLEL DEVELOPMENTS

Complementary with development of the forest industries on this Volcanic Plateau is the construction of a new railway between Putaruru and Kinleith, site of the pulp and paper mills, the opening up of more land for settlement, the completion of the Maraetai and Whakamaru hydroelectric stations, and research into the possibilities of geothermal steam as a source of power. Provision of modern housing and first-class accommodation for single men is a prominent feature of forest-utilisation plans, both in state and private forest areas. At Tokoroa a new township is taking shape while near the government exotic forests at Rotorua and on the Kaingaroa Plains large hostels and other modern amenities have been provided.

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[2] 'Annual Report of the Director of Forestry for the Year ended 31st March, 1949', *Appendices Journ. House of Representatives* (C-3), p. 8.

So far exploitation of exotic forests by the government has been mainly confined to sawmilling and the export of sawn timber to Australia, though it is generally recognised that a more active policy must be pursued if economic loss to the taxpayer is to be avoided. It was the intention to proceed with establishment of a huge newsprint plant at Murupara, some forty miles from Rotorua, on the fringe of the great Kaingaroa Forest. Recently, however, the whole scheme was reexamined and it was indicated that the project is more suitable for development by private enterprise than by the state.

Newsprint has been successfully made from the pulp of pines grown in New Zealand, although tests have been confined to *Pinus radiata* only. Australia has pulp, paper and newsprint industries but, unlike New Zealand, lacks plentiful supplies of softwoods to be self-sufficient in those industries. In Australia today there is probably a market available to New Zealand for possibly 200,000 tons of newsprint and 50,000 tons of kraft pulp per annum. This could be worth £9,000,000 a year to the dominion, with a further £3,000,000 for sawn pine timber.

The Challenge of the Future

Already it is evident that the timber and timber-utilisation industries are second only to agriculture in national importance. Available annual timber supplies from the exotic forests are enormous, and if this asset can be wisely handled and with real vision, enterprise and technical skill, huge industrial developments must result, with great benefit to the nation. Unlike coal, iron and mineral oils, which are exhaustible, wood is a product of climate and soil, and timber crops can always be renewed provided that man directs his energy and abilities in the right directions. World shortages of wood-products, coupled with gross underconsumption among some of the more backward peoples, give ample scope for countries like New Zealand well endowed with usable forests—especially when the trees grow here faster than anywhere else in the world!

New Zealand faces a formidable challenge, calling for every resource of science, labour, management and finance. The exotic forests, together with her rich agricultural lands, can support many times the present population in comparative plenitude and prosperity.

PHOTOGEOGRAPHY

A PICTORIAL SURVEY OF NEW ZEALAND

7. THE WEALTH OF EXOTIC FORESTS

Fig. 1. *Forests and the Volcanic Plateau. Near Rotorua the Green Lake (Rotokaka with its fringing pine forests and volcanic peaks presents a scenic spectacle characteristic the region.*

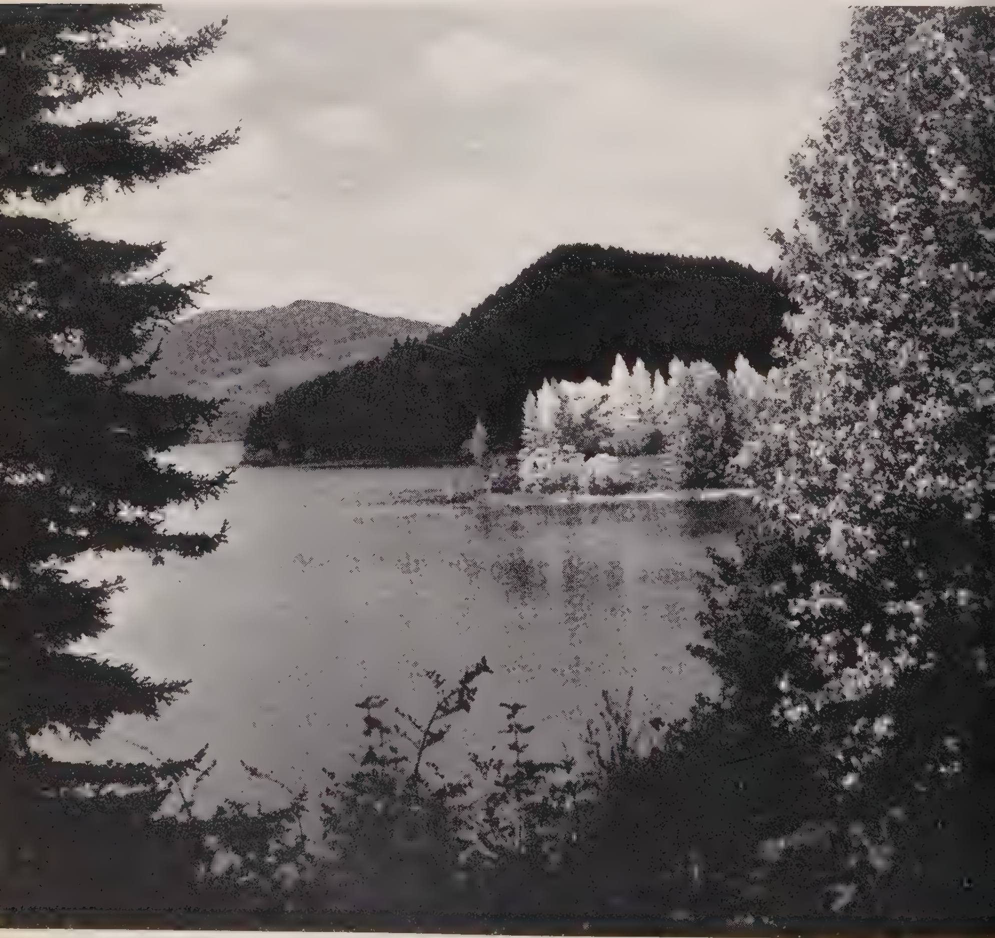

Photo: N.Z. Forest Service

Photo: N.Z. Forest Products

2. *The Volcanic Plateau as it was. A waste of pumice and scrub near Tokoroa thirty s ago.*

TWENTIETH-CENTURY CHANGE

3. *The Kaingaroa Plains today. On the Volcanic Plateau alone more than 800 square s of exotic conifers, state and privately owned, stand symbolic of poor land efficiently sed.*

Photo: N.Z. Forest Service

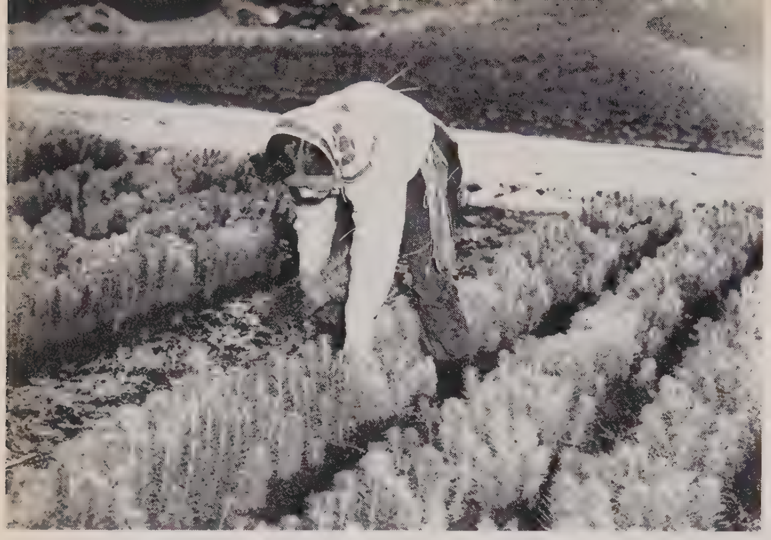

Photo: N.Z. Forest Serv

Fig. 4. *Seedlings of Insignis Pine from the Rotoehu State Forest Nursery.*

FROM NURSERY TO SAWMILL

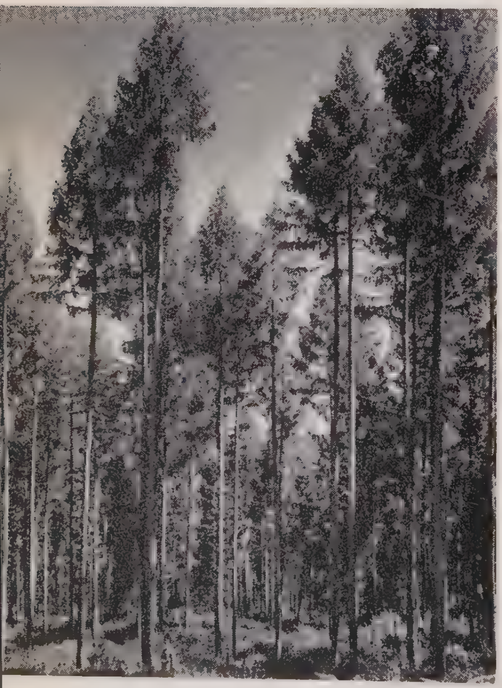

Photo: N.Z. Forest Service

g. 5. *A Mature Stand of European Larch. state forests thinning and pruning are practis- whenever possible.*

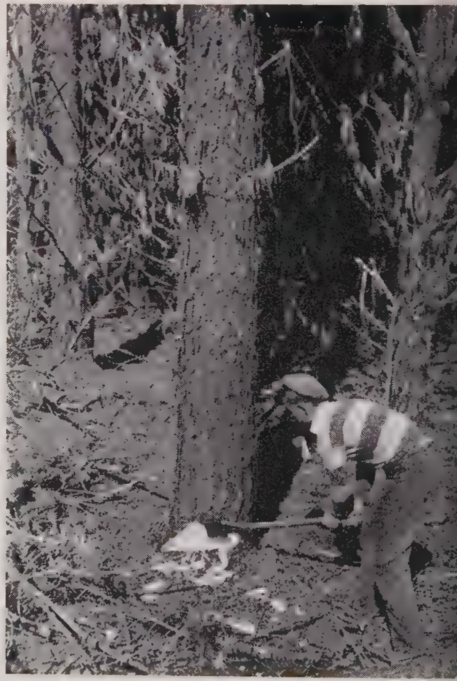

Photo: N.Z. Forest P

Fig. 6. *'Scarfing' a Tree preparatory to F These pines have been neither thinne pruned.*

Fig. 7. *The Logs move from the Forest to . . .*

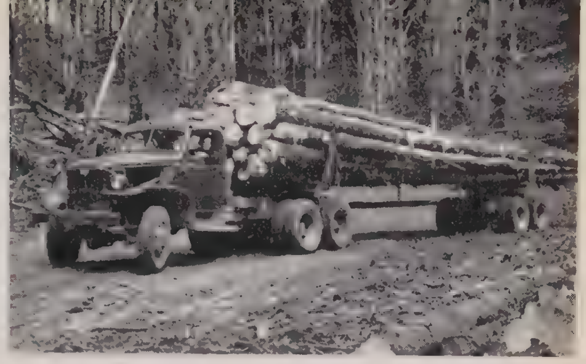

Photo: N.Z. Forest Products

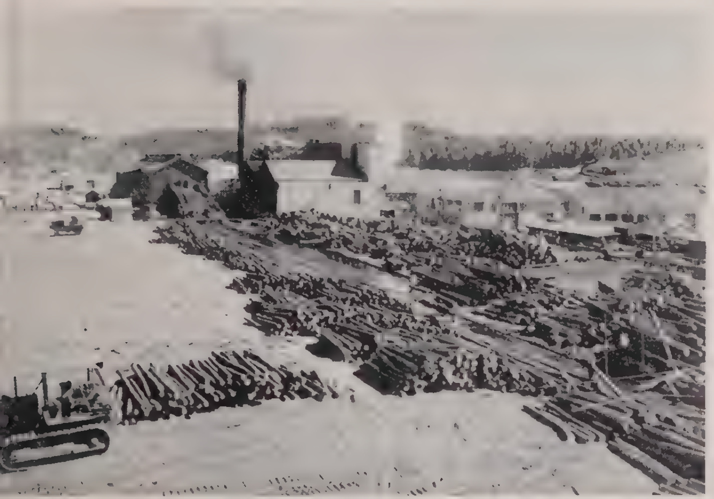

Fig. 8. *The Sawmill Yard, and thence to . . .*

Photo: N.Z. Forest Service

g. 9. *The Framesaws. (Mill and cond framesaw at Whakarewa-wa, Rotorua.)*

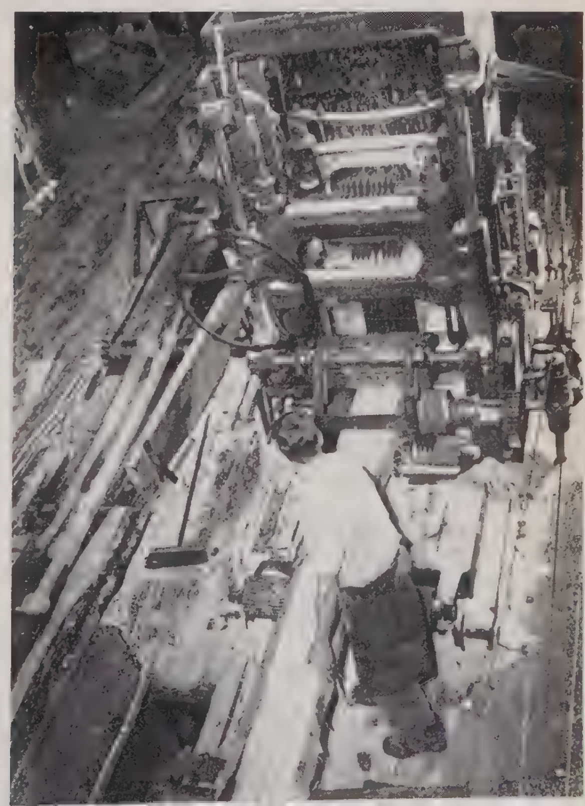

Photo: N.Z. Forest Service

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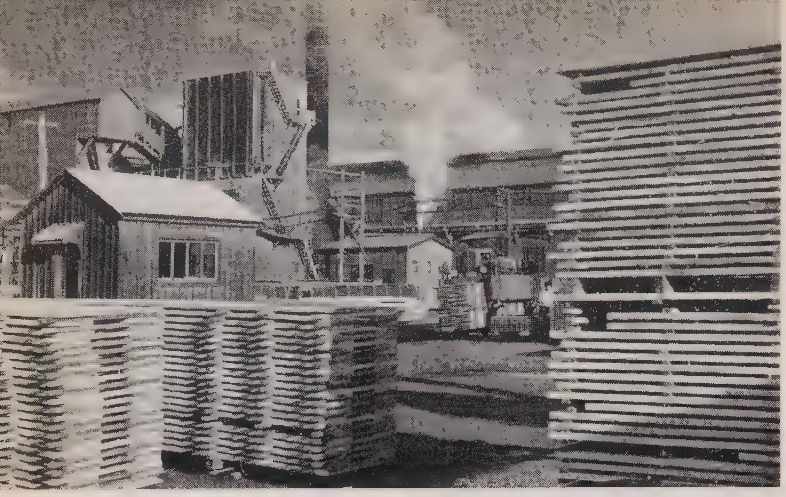

Photo: N.Z. Forest Service

Fig. 10. *Sawn T*

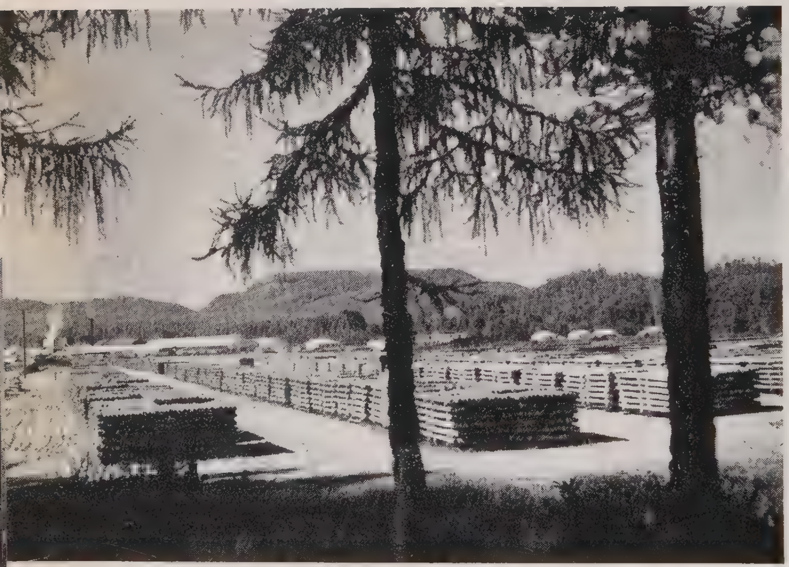

Photo: N.Z. Forest Service

Fig. 11. *Fence P*

Photo: N.Z. Forest Products

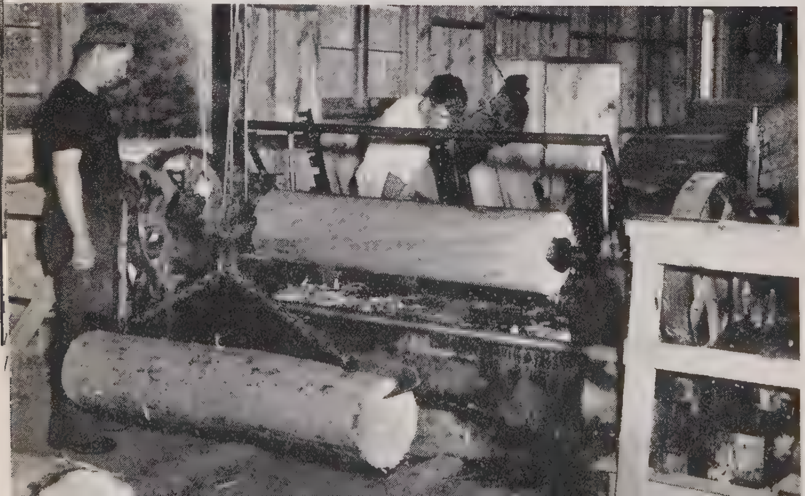

Fig. 12. *Venee*

PRODUCTS
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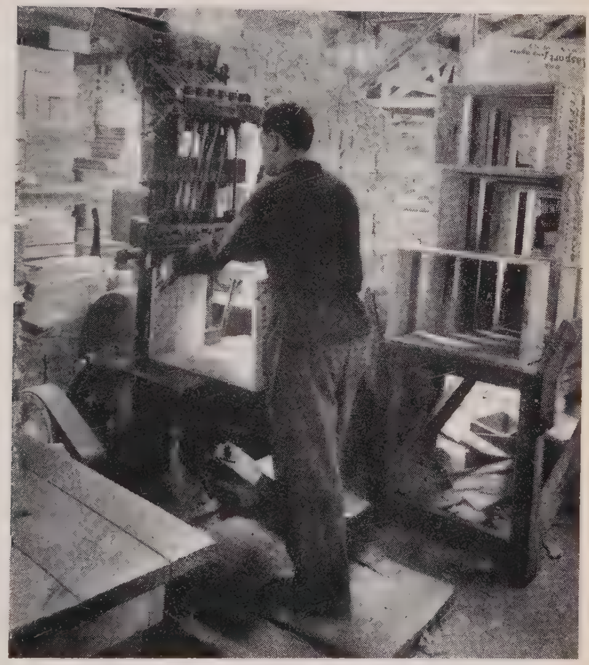
Photo: N.Z. Forest Products



4. Sawn Timber for Boxes
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Photo: N.Z. Forest Products

Photo: N.Z. Forest Products

Insignis Pine
Buildings and
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NEW ZEALAND GEOGRAPHICAL SOCIETY
BRANCH AFFAIRS

Canterbury Branch

Officers for 1951 are— *President:* Mr. J. L. Hewland
Vice-Presidents: Dr. G. Jobberns, Dr. P. R. Woodhouse, Mr. H. M. Sweney
Chairman: Mr. A. C. Pitcaithly
Hon. Secretary-Treasurer: Miss J. Chapman *Hon. Auditor:* Mr. W. Rosenberg
Committee: Miss M. Caine, Dr. G. Uttley, Mr. M. McCaskill, Mr. A. V. Barley, Mr. J. K. Cunningham

It is hoped that the active interest and encouraging attendances at the monthly meetings will continue throughout 1951.

We are pleased to welcome back both Mr. J. L. Hewland, who is taking office as president after one year in England, and Mr. L. L. Pownall, who has joined the staff of Canterbury University College and is now Secretary of the New Zealand Geographical Society. A loss is Mr. A. J. Rose who is taking up an appointment at Armidale, N.S.W. Miss J. Chapman has taken over the office of secretary-treasurer from Mr. M. Spencer who is now living out of Christchurch.

Auckland Branch

Officers for 1951 are— *President:* Mr. L. V. Bryant
Vice-Presidents:
Sir Albert Ellis, Dr. Gilbert Archey, Professor V. J. Chapman,
Professor W. R. McGregor, Mr. L. K. Munro, Dr. E. P. Neale
Chairman: Mr. L. Lucena *Deputy-Chairman:* Mr. A. R. Harvey
Hon. Secretary: Mr. R. G. Lister *Hon. Treasurer:* Mr. W. B. Johnston
Hon. Auditor: Mr. J. K. Bedbrook
Committee: Miss B. M. Williamson, Mr. F. Richardson, Mr. N. Whatman

The year 1950 proved very successful from the point of view of numbers and financial status. Members will be sorry to lose Mr. A. W. Smith who has returned to his duties in the University of Washington, and also Mr. L. L. Pownall whose responsibilities to the society have now become greater with his move to Christchurch in that he is now Secretary to the Society. We are glad to welcome Professor K. C. Edwards, from the University of Nottingham, who is Visiting Professor in the Department of Geography at Auckland University College during Dr. Cumberland's absence overseas this year.

The branch has been active in initiating a scheme for the production of teaching photographs and several issues are planned for 1951. These will be available in the branch area in the first instance but it is hoped in due course to extend the service throughout New Zealand, since the response has so far been extremely encouraging.

The programme of meetings and excursions planned for this year will, it is hoped, prove as attractive to members as in earlier sessions.

Otago Branch

Officers for 1951 are— *President:* Mr. A. H. Payne
Past President: Mr. B. J. Garnier
Vice-Presidents: Mr. G. Simpson, Mr. P. G. Connolly, M.P., Mr. H. I. Sinclair
Chairman: Mr. W. E. Earnshaw
Hon. Secretary-Treasurer: Mr. A. D. Tweedie
Hon. Auditor: Mr. G. S. Kirby
Committee: Miss Coxhead, Miss Bisset, Mr. J. C. Begg, Mr. N. Dew,
Mr. J. Finklestein, Mr. D. Sage

Attendance was good at the two talks which concluded the programme of lectures. In August, Mr. G. A. Holmes, Director of the Invermay Research Station and war-time adviser to the British Ministry of Agriculture, gave an address on 'Modern British Farming'. At the September meeting 'The Geography of Some Diseases' was the title chosen by Dr. G. M. Richardson, Research Officer to the Department of Health, for an informative talk on the geographic distribution and interrelations of epidemic diseases.

The recent departure of Mr. B. J. Garnier to take up his appointment to the Chair of Geography at the University College of Ibadan, Nigeria, accentuates the loss felt by the branch when Mr. and Mrs. R. H. Greenwood left for Queensland. The branch has been pleased to welcome Miss E. I. Elliott who has been appointed to the staff of the Department of Geography in the University of Otago.

[No contribution has been received from the Wellington Branch—Editor]

GEOGRAPHIC NOTEBOOK

CONTRIBUTORS TO THIS ISSUE. During the past six years nearly sixty articles have appeared in the *New Zealand Geographer,* and of these almost half were the work of academic geographers of university status. It so happens that in the present number this proportion has been exceeded, since of the five main articles published three were written by geographers and the fourth by a geomorphologist, all actively engaged in university teaching. The fifth, which describes the utilisation of exotic forests in this country, has been contributed by Mr. Clive Tidmarsh, Public Relations Officer to New Zealand Forest Products Ltd. Mr. Tidmarsh possesses first-hand knowledge of timber development by private firms in New Zealand, and has in many ways inspired in his countrymen a respect for the immense resources embodied in the exotic forests of the dominion. His present short article will further enhance that appreciation.

Of the other four contributors, two have left New Zealand. Mr. Howard J. Critchfield has returned to the University of Washington at Seattle after spending two years as a Visiting Lecturer in Geography at Canterbury University College, Christchurch. Mr. Critchfield has no mere passing acquaintance with Southland. During vacations he was actively pursuing research in this southernmost 'province' of New Zealand and he will eventually present his findings in a dissertation for the Ph.D. Degree in the University of Washington. Meanwhile he has recorded some of his impressions of pastoral Murihiku, and as an American intent on objective survey he will no doubt be spared the calumny of having a 'parochial attitude'.

The second geographer to leave these shores is Mr. B. J. Garnier, who has accepted the Chair of Geography in the University College of Nigeria at Ibadan. As Senior Lecturer in the University of Otago since 1946, Mr. Garnier has contributed much to the development of geographic studies both in Dunedin and in New Zealand as a whole. His particular interests have lain in climatology, a field he has made distinctively his own among New Zealand geographers. His present paper contributes to the greater understanding of regional differences in the availability of soil moisture, and provides a basis for future work of prime significance to farmers and to workers in the sphere of soil conservation.

Professor C. A. Cotton contributes a short paper on some of the characteristics of the southwestern part of the Wellington fault. Professor Cotton occupies the Chair of Geology at Victoria University College, Wellington, and needs no introduction, for he is a geomorphologist of world renown. Moreover, by his interest and encouragement, he has stimulated the development of geography, *qua* geography, in New Zealand. Mr. L. L. Pownall, too, is known to readers of the *New Zealand Geographer.* His investigations into the geographic character of metropolitan Auckland were undertaken whilst he held the post of Lecturer in Geography at Auckland University College, and his article in this issue provides a sequel to one published in the preceding number (Volume VI, Number 2). Mr. Pownall has now been appointed Senior Lecturer in Geography at Canterbury University College, and will no doubt continue his research in the urban centres of the South Island.

Further contributions in the form of notes, commentaries and reviews have been made by: Professor G. Jobberns and Mr. Maxwell Gage of Canterbury University

College; Mr. T. H. McCombs, Member of Parliament for Lyttelton and the Chatham Islands; Mr. L. V. Bryant, Headmaster of Pukekohe District High School; Mr. R. K. Wilson of the University of Melbourne; Dr. D. J. Patton, Mr. A. J. Rose and Mr. P. N. Dent, formerly of Canterbury University College; Mr. L. P. Lee, formerly of Head Office, Computing Branch, Department of Lands and Survey, Wellington; and the Editorial Staff.

The index and contents sheets to the *New Zealand Geographer*, Volume VI, have been prepared by Miss A. M. Iverach and are sent out with this number.

PROGRESS IN FARMING. The economy of New Zealand is dependent to a major extent upon the breeding of livestock. Many urban dwellers tend to forget this, and think of farmers as people who need merely to sit and watch their animals multiply. The *Annual Report* of the Department of Agriculture for the year 1949-1950 should help to dispel this illusion. Although dealing with the activities of the various divisions of the department, this report also indicates, indirectly, some of the problems faced by the farming community in New Zealand. It is a brief guide to what at first appears to be a comparatively uncomplicated industry.

The activities of the several divisions appear to overlap to a certain degree, and it is surprising to learn that there is no division dealing solely with the sheep industry as there is for the dairy industry. Most diversified in its field of activities is the Extension Division. In addition to executing its primary task of rural education this division carries out research projects of its own. The Winchmore Irrigation Research Station, Canterbury, a farm of 350 acres, has been steadily developed. On country that formerly carried one ewe to the acre it has been found possible, even in the early stages of irrigation, to double the carrying capacity. Under irrigation it would probably now be feasible to convert much of Ashburton County to dairying should this be economically desirable. In the same general area wheat acreages have again declined, and it is unlikely that there will be any great increase in this vital crop until such times as local prices are brought more into line with those ruling on the world market. In the quantity of small-seed production there has been little variation from the previous season. Although figures of total seed production are not given those for certified seeds are recorded. Most important of these seeds was perennial ryegrass (575,905 bushels) and white clover (2,724,508 lbs.). Short rotation ryegrass (115,309 bushels) is now far more popular than Italian ryegrass (26,876 bushels).

In pasture production greatest attention has hitherto been concentrated on the high-producing strains for better-class land. A more balanced view appears to be developing with attempts to increase the productivity of low-quality hill pastures. Efforts along these lines have been greatly facilitated since the war by the expansion of aerial sowing and topdressing with concentrated fertilisers in hitherto inaccessible localities. As the key to highest pasture production in any sward is the establishment of clover, experiments with this end in view have been continued in widely scattered areas. In general it has been found that subterranean clover is most suitable for the drier areas, white clover for humid localities, and *Lotus major* for hill areas in wet districts. But over much of New Zealand's hill country it will be necessary to destroy great areas of scrub, fern and second growth if maximum utilisation is to be achieved. This is a problem which has yet to be solved to the satisfaction of both farmers and conservationists alike, and it is intimately linked with the improvement of the fertility of the hill-country soils. In certain depleted tussock areas, notably in Central Otago, it has been found impossible to carry out pasture improvements until rabbits, burning and overgrazing are brought under strict control.

In contrast to the Extension Division the Animal Research Division limits its activities to pure research. The field of flock improvement is one which holds great promise and experiments have been continued. Footrot is a problem which has long troubled farmers, especially those on heavy land. The conclusion reached by the division is that any farmer who has sheep-proof fences can eradicate footrot provided he is prepared to exercise extreme care and to work hard and long. Further experiments with artificial insemination of dairy cattle show that certain difficulties have yet to be ironed out before a nation-wide scheme of application can be adopted. Some light is shed on a further problem which has given dairy farmers concern. Results from experiments 'suggest that an allowance of approximately 100 lb. of butterfat must be made in comparing the records of cows well fed on grass with those whose diet is supplemented with concentrates to assure maximum yields. This point is of considerable practical importance in the selection of bulls either on the butterfat backing of their dams under New Zealand conditions or on the production of their progeny'.

The ten-year tables of butterfat for export given in the report of the Dairy Division show a steady rise over the past four years. However, the 1950 total butterfat equivalent was only 3289 tons greater than the figure of 160,466 tons for 1941. In the years between, the figures dropped as low as 112,516 tons (1944). It is probable that as long as dairy farmers can make a competent living from their present production a great increase in butterfat production is unlikely. In a country which prides itself in the general efficiency of its dairy industry it is surprising to find that dairy inspectors have rated, from the viewpoint of sanitation, only 13.8 percent of New Zealand cowsheds as good, 54.9 percent fair, and 31.2 percent bad. Corresponding figures for milking machines are 18.9, 54.2 and 26.9 percent.

Some miscellaneous information from other parts of the report may indicate the breadth of the field in which the department works. 96,368 pig carcasses, or fourteen percent of the total killings during 1949-1950, were found to be affected with tuberculosis in varying degree. Mastitis in dairy herds appears to be almost under control, thanks to the use of penicillin. Power-spray dipping of sheep using equipment imported from Australia is rapidly increasing. Rabbit boards were granted £439,812 for control measures, but little progress was made in the control of noxious weeds. And an item which may cause surprise; there are 6487 beekeepers in New Zealand, about two-thirds of whom practise in the North Island, while the value of bee stocks and plant based on present holdings in New Zealand is estimated at £1,217,000.—A. J. Rose

MIGRATION TO AUSTRALIA. There has been a continual enlargement of the size and scope of the Australian immigration programme in the postwar years. The reasons given by the former Minister for Immigration, Mr. A. A. Calwell, were that additional population was needed, both for more adequate defence in the face of a future potential threat from the 'Near North', and for fuller development of unused or underused resources. Current immigration policy was first formulated in 1945 when a figure of two percent per annum was accepted as about the maximum effective absorptive capacity of the country. This two percent includes both the natural increase and gains from migration. Two percent of the total population is approximately 140,000, and since natural increase had averaged 70,000 in the five years prior to 1945 this left a migration target of 70,000 a year. However, natural increase has added annually at least 100,000 to the total population since 1946, so that adherence to the proposition that no more than a two percent annual increase in population was desirable would have reduced planned annual immigration to approximately 40,000. In fact 1947, the first year of planned immigration, yielded only 31,765 permanent arrivals, and since nearly 20,000 Australians left the country permanently, net immigration totalled only 12,186.

However, in the same year plans were made to double the original figure by expanding immigration from the United Kingdom, and at the same time selecting an equal or larger number of displaced persons then under the care of the International Refugee Organisation in Germany. These newcomers were required to enter undermanned industries at government direction and remain employed in them for two years. Their employment in such places as brickworks, tile factories, timber mills, and other such establishments supplying the housing industry with basic materials tends to justify the arrival of large numbers when a continuing acute housing shortage arouses feeling against immigration. On the other hand recent studies have indicated that no real expansion of the building industry is to be expected for some years, and both State and Federal Governments are proposing to import a large number of prefabricated housing units from Europe, thereby attempting to keep pace at least with population growth. Since 1947 this growth has risen to unprecedented heights when natural increase and immigration are considered together.

In 1948 the net gain to Australian population was approximately 150,000 and in 1949 a quarter of a million, the latter figure representing an annual increase of more than three percent of eight millions, the figure which the total population has recently exceeded. The figure of 149,000 immigrants in one year has never been reached before, if the exceptional circumstances of 1919 be excepted when troops returned in large numbers. Nor has it ever been the case before that in a large influx into Australia three-fifths of the immigrants should be other than British. The bulk of the non-British migrants were former displaced persons, of whom more than 100,000 had arrived in Australia by the end of 1949, the remainder being Italians, Greeks and other Europeans. No reduction of migration is planned by the new government which came into power in 1950. In fact the Minister for Immigration declared, 'Two and a half percent is our target for this year. It consists of 200,000 migrants (100,000 of them British), and 50,000 by natural increase'.

Granting these figures, 250,000 would represent more than three percent, but 50,000 added by natural increase seems only half of what might be expected in view of the corresponding figures for 1946-1949, and it would seem rather that 300,000 is more likely to be the net gain. This would represent a 3.75 percent gain in 1950, a very rapid increase, and perhaps an alarming one if the opinion of an expert demographer be considered: 'It is questionable whether any country, even in most favourable circumstances, could absorb on the average over any prolonged period more than two percent of its total numbers.' (W. D. Borrie: *Immigration, Australia's Problems and Prospects,* Sydney, 1949, p. 13.) There would be less room for disquiet if this were merely a short-term enlargement of plans, but it is proposed that this accelerated rate will continue indefinitely. Mr. R. G. Casey, Minister for Development, has declared that 'migration policy is planned to double the population in a generation'.

Ideally the growth of population should keep in step with the growth of capital investment and economic activity. If living standards are to be maintained, capital accumulation must keep pace with population growth, and if they are to continue to increase the former should exceed the latter. There is no certainty that the expansion of capital investment will be commensurate with population growth, particularly since much recent British investment has probably been made in the hope of a forthcoming revaluation of the Australian currency. Considerations such as these cast some doubts on the wisdom of continued large-scale immigration, but in practice the decision will be largely political. More precisely, as long as full employment is maintained in Australia and migrants acceptable to Australia are prepared to leave Europe, migration may be sustained. A spectacular beginning has been made but perhaps the chances of doubling Australia's population in a generation are somewhat slim.—R. K. WILSON

AUSTRALIAN COAL AND STEEL. One of the most disappointing features of Australian production in the postwar years has been the failure of the New South Wales coal industry to meet the expanded demand for its product. All states except Queensland depend to a greater or lesser extent on the New South Wales industry, which normally supplies eighty percent of the black coal mined in Australia.

NEW SOUTH WALES COAL PRODUCTION (TONS)

Year	Open Cut	Underground	Total
1939	—	11,149,000	11,149,000
1942	57,000	12,149,000	12,206,000
1946	756,000	10,430,000	11,186,000
1947	959,000	10,724,000	11,683,000
1948	1,254,000	10,467,000	11,721,000
1949	1,347,000	9,389,000	10,736,000

Production in 1949 at 10,736,000 tons was nearly four million tons short of demand. Largely because of a protracted general strike, underground production was the lowest since 1936, and only the increasing quantity of coal won from open cuts in New South Wales and some other states, and some imports from overseas, prevented the coal crisis throughout Australia from being more serious than it was.

In 1946 the Commonwealth and New South Wales Parliaments passed Acts which set up a controlling authority, the Joint Coal Board, to regulate, assist and rehabilitate the coal industry in New South Wales within the framework of private ownership. The board has striven manfully to expand the capacity of the industry, to modernise and mechanise mines, and to improve employer-employee relationships. However, it does not now expect that production will meet demand until 1953 as the following estimates show:

FORECAST OF NEW SOUTH WALES COAL PRODUCTION (TONS)

Year	Production	Requirements	Margin
1950	13,000,000	15,800,000	– 2,800,000
1951	14,200,000	16,500,000	– 2,300,000
1952	16,100,000	17,300,000	– 1,200,000
1953	18,800,000	18,000,000	+ 800,000

This forecast has led the Commonwealth Immigration Planning Council to recommend the purchase by the Federal Government of one million tons of overseas coal to tide industry over the shortage. State Governments are also placing orders for overseas coal, but this will cost considerably more than the local product. For example South African coal of approximately the same calorific value as that from New South Wales, imported by South Australia in 1949, cost between £5 and £5 10s. a ton as compared with £3 5s. a ton for New South Wales coal. In the postwar period the Australian economy is suffering an acute shortage of capital equipment and basic industrial materials; for example, houses and building materials, rolling stock, ships and steel, electric generating plant, and industrial machinery, and unless the coal problem is solved soon some of these shortages will become chronic.

Production of steel in the postwar years has been much below the capacity of the Australian industry, mainly because of shortage of coal and only secondarily because of a shortage of labour.

AUSTRALIAN STEEL PRODUCTION (TONS)

Year	Steel Ingots	Percentage: Estimated Capacity
1939	1,169,000	62
1942	1,697,000	97
1946	1,055,000	60
1947	1,312,000	75
1948	1,343,000	77
1949	1,129,000	65

The above figures exclude a very small amount produced outside New South Wales, an amount which did not become significant until March 1949 when a single electric furnace began production of steel at Whyalla, South Australia. The estimated capacity of the industry is normally regarded as 1,750,000 tons, and in spite of the recent underuse of this capacity, a new blast furnace and additional open hearth furnaces are being built at Port Kembla, New South Wales. This will raise the estimated capacity to over two million tons of steel annually. As would be expected, Australian steel exports (mainly to New Zealand) have declined while imports have risen. Large orders have been placed with overseas producers; for example, with Japan for £1,000,000 worth at almost double the price of the Australian product, and with France for £1,000,000 worth of steel rails, a product which the local industry is capable of producing. It is probable that under normal conditions the Australian industry could meet all home needs with the exception of tinplate and a few special steels, but it seems unlikely that the coal position will improve sufficiently during the next two or three years to allow it to do so.—R. K. WILSON

THESES IN GEOGRAPHY. Theses presented by postgraduate students during 1950 included for the first time two submitted for the Degree of M.Sc. in the University of New Zealand. Thereby geography attained full stature as both an arts and a science subject in the University of New Zealand. No doubt future years will witness the presentation of increasing numbers of masterate theses by students of geography who have had a grounding in one or more of the natural sciences. 1950, too, was the first year in which a masterate thesis emanated from the University of Otago.

Topics again covered a wide range; from town studies through county surveys to a dominion-wide investigation, from the field of geomorphology to that of economic geography, and from the regional characteristics of rural land utilisation to the contribution made by geography in the planning of land use in a metropolitan area—in short, a fair sample of the postgraduate work at present undertaken in geography for masterate degrees.

The theses presented during 1950 are listed below—

From Canterbury University College:

Some Geographical Aspects of Ellesmere County, P. N. Dent;
Industry in the Northern Section of Metropolitan Christchurch from Papanui to Belfast, C. E. Devonport;
Wheatgrowing in the Ashburton County, T. F. Kennedy;
Recent Changes in the Sumner Foreshore and Estuary, B. R. Pearse;
The Esk River Catchment, Canterbury, M. Spencer.

From Auckland University College:

Morrinsville: A Study in the Integration of a Town and its Region, E. B. Allison;
The Plant Geography of the 'Far North', New Zealand, R. S. Dick;
Agricultural Land Use in Waitemata County, A. J. Henley;
Some Aspects of the Medical Geography of New Zealand during 1946 and 1947, J. W. Quinn;
The Agricultural Geography of the Bay of Plenty, W. A. Snelling.

From the University of Otago:

Metropolitan Dunedin: A Geographic Contribution to Land-Use Planning, A. D. Tweedie.

Copies of these theses are housed in the respective college libraries.

IN OUR CONTEMPORARIES

1. *In New Zealand Journals . . .*

An Eternal Problem: Too Much or Too Little

GROUND WATER IN NORTH CANTERBURY: B. W. Collins, *New Zealand Journal of Science and Technology,* Vol. 30, No. 5, March 1949, pp. 249-268.

In this examination of the behaviour of ground water in North Canterbury, Mr. Collins has done first-class work of direct practical value and interest to many people. Ground water in Canterbury has been much discussed during the last decade or so, and common beliefs concerning it have not always been very soundly based. In the early days many extensive swamps were drained to produce excellent farmland, but as the land was subdivided into small farms provision was rarely made for maintenance of drains. Consequently this ground has tended to get more and more waterlogged in wet seasons. In mid-Canterbury, for example, many farmers n the wet country have lately tended to blame the Rangitata-Rakaia diversion race for all the trouble caused, few being ready to admit the likelihood of its being related directly to abnormal rainfall. Similarly in 1945 many farmers in the area between Rangiora and Oxford suffered a good deal from a general rise in the ground-water level following heavy rains and flooding of rivers, the trouble being most acute in the area covered by the old Rangiora swamp into which the Eyre and Cust Rivers used formerly to find their way. In response to their requests for help, he North Canterbury Catchment Board planned a comprehensive scheme for drainage and flood control in all the country between Oxford and the sea, but by he time this had come before the ratepayers for their approval, considerable opposition was aroused and the behaviour of ground water locally was vigorously discussed. The scheme sponsored by the catchment board involved diversion of the upper Eyre into the Waimakariri and the Cust into the Ashley, thus leaving the lower ourses of these streams to serve as channels for drainage of the lower country in imes of flood.

A succession of dry seasons followed the wet weather of early 1945, the water able fell, and farmers became equally concerned about a dependable supply of water in their domestic wells. Many believed that the supply of their well water depended directly on flow in the Eyre and Cust Rivers, and it is especially for his xamination of this common belief that Mr. Collins's paper is so valuable. For many years he collected rainfall records and information from farmers on the fluctuation of water level in their wells. He also studied the character of the water-bearing beds as closely as this could be done in such country, and has been led inevitably o the conclusion that rainfall soaking into the porous shingle of the high plains s the direct source of most of the ground water. In his opinion, seepage from the ed of the Eyre River must have a relatively minor effect.

Incidentally Mr. Collins calls attention to an aspect of the structure of the plain hat has a more general interest. He finds that, underlying a veneer of freely porous urface shingle, is a much more compact and relatively impervious gravel. This points to the probability that the history of the formation of the Canterbury Plains is somewhat more complex than early observers considered it to be. However this paper is a notable contribution to a difficult subject. It is easy enough to observe the behaviour of surface water, but when it soaks into the ground its movement is much more difficult to trace.—G. Jobberns

Land Use in North Canterbury

FARMING IN NEW ZEALAND; RANGIORA AND EYRE COUNTIES:

P. van Praagh, *New Zealand Journal of Agriculture,* Vol. 80, No. 4, April 1950, pp. 353-366.

Continuing the series 'Farming in New Zealand' this article contains a comprehensive account of farming in the North Canterbury counties of Rangiora and Eyre. Adequate climatic data is given on rainfall characteristics, frost, hail and snow, together with details of winds and sunshine. A detailed but rather tedious description is given of some twenty-six soil types recognised by the soil surveyor and there is a map of soils distribution, which in the absence of colour printing or differential shading could profitably have been generalised even further. Farm-management problems in the area are closely linked with drainage problems and the seepage of underground water, and a brief account of these features completes the analysis of soils and climate.

The body of this article is a study of land utilisation and its changes over the past thirty years. Three maps showing main towns and railways, the distribution of beehives and the principal systems of farm management are supplemented by diagrams indicating the relative acreages of cereals grown and livestock statistics from 1920 to 1947. Crop production includes consideration of small seeds and cash crops of wheat, oats, barley, potatoes, peas, linseed, linen flax and honey, and illustrates the great diversity of agricultural products in this part of North Canterbury. The significance of forage crops—rape, choumoellier, turnips, swedes and mangolds—further emphasises the arable nature of the agricultural practices. Livestock, although less important throughout most of the area, are considered in some detail. Dairy cattle receive special consideration, and up-to-date information on recent trends and their implications is provided.

The map showing types of farm management is accompanied by descriptive details of land management, farm products, land values and associated soil types. Several well-chosen photographs give some impression of the contrasts in land development. Although the distribution of beehives as portrayed on a map has some significance, one is tempted to suggest that a map displaying the intensity of cropping in different parts of the area or the distribution of livestock would have been of greater value. A map depicting variations in the size of holdings, so apparent in the area itself, and the relative density of population might have given additional depth to the picture of farms and farming within the area.

This article, precise in its style and accurate in detail, is a welcome addition to the geographic and agricultural literature of Canterbury.—Peter N. Dent

2. *In Overseas Journals . . .*

Oceans and Earth History

THE LEITMOTIF OF THE TECTONIC DEVELOPMENT OF THE EARTH: H. Stille, *Deutsche Akademie der Wissenschaften zu Berlin, Vorträge und Schrifte*, Hefte 32, 1949, pp. 1-27.

THE ORIGIN AND PASSING OF CONTINENTS AND OCEANS: H. Stille, *Die Erde*, Hefte 1, 1949, pp. 12-37.

These semipopular lectures summarise conveniently the conclusions reached after many years of research during which Stille's labours have converged on the explanation of the origin of the present-day continents and ocean basins, and so have become of geographic as well as palaeogeographic interest. Bound up with this has been his study of orogenies, particularly his recognition of orogenic paroxysms both as builders of continental lands and as punctuation marks in the stratigraphic record of geological time. He recognises some geographic features as being of vast antiquity, and attempts to date outstanding events and stages of their development over a span of 1000 million years. Such studies have led him to expand the list of orogenies beyond the few commonly recognised—the Caledonian, Hercynian, Laramide and Alpine. He counts some forty or fifty as occurring since the beginning of the Palaeozoic era, and believes that these spasms of folding and compression have affected widely separated regions simultaneously, and, moreover, that they have passed quickly, each occupying no more than perhaps a hundred thousand years. It is obvious that if there have been paroxysms of world-wide deformation as short-ived as this, and if, as Stille believes, relatively lengthy intervening periods have been anorogenic, not merely in restricted regions but throughout the world, and if, further, it be possible to pinpoint in the geological column the many orogenies that have occurred, then a method is available for dating some of the events of the past very precisely.

In parenthesis it must be stated that the foregoing thesis does not present itself as plausibly to all other geologists as it does to Stille and his school. It has been criticised recently by Rutten, of Holland, and by Gilluly as president of the Geoogical Society of America. Reasoning in a circle may falsify dates claimed as precise; the orogenic paroxysms must, as they are discovered, be dated by palaeontoogical and stratigraphical methods, a dating which is quite commonly vague to the extent of a span of a good many millions of years. This leads to doubtful accuracy of correlation across the world. Moreover, intense study of a particular system or group of stratified formations in a restricted region, such as California, tends to multiply surprisingly the number of known breaks in the continuity of deposition which must be attributed to crustal folding. Either these are to be regarded as local disturbances only, in which case the theory that all orogenies are potentially world-wide breaks down, or, by extrapolation, it must be inferred that the orogenies interrupting the continuity of the geological column are vastly more numerous than even Stille has supposed, thus making distant correlations most hazardous. It is impossible to ignore an alternative view that there always is, and that there always has been, differential movement and perhaps even intensive deformation in progress in some part or other of the world. There may be no ground for claiming that any particular folding in New Zealand, for example, has been strictly contemporaneous with folding in other regions. Differential movement is going on vigorously at present in the seismic middle districts of New Zealand (as has been recognised recently by Gutenberg and Richter in *Seismicity of the Earth,* Princetown, 1949), but according to Stille the last orogeny, of short duration and long since over, was the Pasadenan, of middle Pleistocene date, and this has been succeeded by one of the longer-enduring periods of crustal stability and world-wide immunity from folding.

Though any attempt at a very fine subdivision of geological time by this means may be deprecated, there may still be a good deal in the widely accepted theory of periodicity, the theory that, as Gilluly phrases it (though not convinced of its validity), 'during . . . episodes of storm and revolution parts of the crust widely scattered over the earth have been simultaneously strongly deformed'. On such 'geotectonic' basis Stille cuts all decipherable geological time into two great divisions, Protogeic and Neogeic, separated about 800 million years ago by the great Algomian orogeny, which was followed quickly by the Algonkian 'breaking down' (*Umbruch*) of former lands of vast extent so that they became submerged. The Neogeic he subdivides into four eras separated by major orogenies followed by the 'regenerations' (i.e. reestablishment of geosynclinal conditions) which usher in the Cambrian, Devonian and Triassic periods of the older-fashioned chronology. These eras of geosynclinal accumulation, each culminating in a major orogeny, are named from the orogenies Assyntic, Caledonian, Variscan and Neoidic. Stille consistently employs this chronological nomenclature in his interpretation of earth history.

Stille's study of the oceans has resulted in his adoption of a modified theory of permanence. Oceans in his category of 'primitive' (*Urozeane*) may be described as permanent; but besides these there are also 'new' oceans. The five primitive oceans, *Urpazifik, Urarktik, Urskandik* (between Greenland and Norway), and North and South *Uratlantik* (originally separated by land) have heavy floors of sima. They are surrounded by folded and faulted margins in which structural lines are parallel to the ocean borders because the highly rigid sima floor has acted as a 'backland' against which the crust in marginal lands has been deformed by thrusting. They date from very early times, perhaps Archaean. Contrasting with these permanent primitive oceans, continental landmasses may decrease or increase in area as geosynclines develop and become submerged, are filled with sediment, and are rucked up by folding so as to become land again. New oceans have been formed in the Neogeic by sinking of lands and are associated with geosynclinal regions.

Present-day oceans are partly in the primitive (*ur*) and partly in the modern (*neu*) category. The largest example of a new ocean is the Indian, which contains remnants of foundered lands and has acted in places as a foreland for orogenies. Also, the structural lines in some folded bordering regions, being more ancient, are not parallel with the boundary of the ocean. The Atlantic is of 'mixed' origin, comprising two small primitive oceans joined and enlarged by portions that are new.

To the Algonkian breaking-down period at the end of Protogeic time is assigned the geosynclinal subsidence of vast areas bordering the primitive Pacific and Arctic basins and also extending in broad belts across Eurasia and other parts of Megagea, the single continent of the Protogeic. Prior to this enlargement, the western boundary of the Pacific Ocean is made by Stille to coincide with the andesite (or Marshall) line.

Such geosynclinal sinking serves to reduce the rigidity of the former land. The geosynclines become filled with stratified formations which yield readily to compression by folding, thus lending mobility to the tract containing them; but when these have been folded by orogeny such a tract is not only restored to continental status but also regains rigidity, to which injection of granite generally makes a further contribution. Such, according to Stille, are causes that have contributed to interchange of sea and land and the development of existing ocean boundaries.

Stille's map of Megagea may suggest comparison with the hackneyed representation of Wegener's Pangea. Stille almost ignores the theory of the breaking-up of the primitive continent by continental drift; but his vast collection of data may be regarded as a massive refutation of drift theories, especially that of Wegener, with its late dating of fragmentation.—C. A. COTTON

SOUTH ISLAND GLACIERS

FRANZ JOSEF AND OTHER GLACIERS OF THE SOUTHERN ALPS, NEW ZEALAND: R. P. Suggate, *Journal of Glaciology*, Vol. 1, No. 8, October 1950, pp. 422-429.

Renewal of interest in the properties and behaviour of natural ice and in studies of existing glaciers may be measured by the expanding membership of the British Glaciological Society and the successful launching of its *Journal*. Authoritative reports of the New Zealand glaciers are not many, and some are not readily available overseas, so that Mr. Suggate's bibliographic review will be as welcome as his enquiry into the causes of recent glacier fluctuations. The review does not pretend to offer an exhaustive list, but it is perhaps surprising that there is no reference to the writings of Haast, nor to the existence of information of glaciological value scattered through the journals of mountaineering clubs.

Observations of the rates of glacier flow in New Zealand are few and for the most part unsystematic. Statistical treatment is not yet possible and comparisons can thus easily lead to erroneous conclusions. The maximum rates, for example, recorded on several glaciers at different times and different distances from their snouts, show an extraordinarily wide range of variation. Seasonal differences are suspected, and may account for the apparently anomalous faster flow of the Fox Glacier at the nearer of two stations to its snout.

The Franz Josef and Fox Glaciers in Westland and many small glaciers on the eastern side of the Alps have retreated considerably since the early 'nineties, whereas the Tasman and other large eastern glaciers, although fed from the same or nearby snowfields, show little or no retreat. There is nevertheless abundant evidence of vertical downwasting. Mr. Suggate points out that the lower parts of many eastern glaciers are protected from surface ablation by superglacial debris. As a partial explanation, this is supported by the contrast between two Upper Rakaia Glaciers. During the past eighty-five years the Lyell Glacier has gone back nearly two miles, while the neighbouring more heavily moraine-covered Ramsay Glacier has retreated ess than half a mile.

The most complete records are those of the Franz Josef, which almost held its ground between 1893 and 1909, retreated about 500 feet before 1920, regained most of the lost ground by 1934, and then began a spectacular retreat which carried the snout back in 1946 to more than half a mile from the 1909 reference point. The readvance which then commenced was continuing at the rate of one foot per day in October 1949.

Mr. Suggate has assembled weather information from the nearest stations which possess suitably long records, namely Hokitika and Ross, sixty-five and fifty miles respectively from the Franz Josef. He shows graphically that retreats followed cumulative deficiencies of rainfall at both stations, and advances followed cumulative surpluses, with a time lag of about five years. The influence of the prevailing westerly precipitation is clearly important, but as the agreement is limited to the direction of change and is apparently not quantitative, other factors are involved. It is shown further that the main advance occurred during a succession of years of below-average temperature at Hokitika, and the high sunshine records between 1920 and 1935 may help to explain why the rainfall excess of the early 1920's failed to produce a spectacular advance. On the other hand, the last ten years of sunshine gains were accompanied by a cumulative decline in precipitation, accounting perhaps for the rapidity of the great retreat.

It is to be hoped that Mr. Suggate's work will arouse greater interest in glacier studies in this country, and that he will be able to pursue his promising investigation of the meteorological causes of glacier advance and retreat, a fundamental part of the broader question of the causes of widespread glaciation. His appeal for systematic photographic records of at least the accessible glaciers is likely to receive the support of all physical geographers, but it is desirable also to consider the practicability of obtaining regular and complete meteorological records close to the glaciers.

—MAXWELL GAGE

REVIEWS

Of Men and Mountains

UNCLIMBED NEW ZEALAND: ALPINE TRAVEL IN THE CANTERBURY AND WESTLAND RANGES, SOUTHERN ALPS. By John Pascoe. London: George Allen and Unwin Ltd., 1950, pp. 238.

The appearance in 1939 of the first edition of Mr. Pascoe's book was doubly welcome. In the first place no new book on the New Zealand Alps had appeared for many years, and secondly this book broke ground unfamiliar to most New Zealand climbers as well as to overseas mountaineers. It is more than pleasing to see that the demand has been such that Mr. Pascoe and his publishers have felt encouraged to produce a second edition.

Mr. Pascoe feels that too many are attracted to the highest Alps of New Zealand and fail to experience the great attraction of the lesser known parts of the Southern Alps. He shows that exploration in these less accessible regions is just as attractive, if less technically difficult, than the ice climbs of the Hermitage region. Mr. Pascoe has been one of the most energetic members of the Canterbury Mountaineering Club which has carried out splendid exploration work in the Rakaia, Rangitata, Perth and Adams Valleys, to mention perhaps their main fields of adventure. This club has certainly recaptured the joy of the first generation of mountaineers. As Mr. H. E. L. Porter says in a really excellent foreword: 'The young men of Canterbury have fed the flame of their youth with gallant deeds, and will keep it alive as the years creep on with happy memories'.

New Zealand possesses one of the finest mountain ranges in the world, and though it cannot claim the remarkable variation of the Alps of Europe, yet the extent of its glaciation is astonishing, while the icefalls and ice ridges equal anything outside the Himalaya. These Southern Alps are perhaps the finest training ground in the world for Himalayan work, and the author quite rightly states that 'New Zealanders do not have to migrate to the Himalaya to encounter exceptional mountaineering difficulties'. The monsoon can hold few greater terrors than the New Zealand Nor'wester.

This book is largely a record of the forceful part played by the author in the enthusiastic exploration of these more northerly valleys. It is modestly, yet attractively and vividly written. He has made himself an authority on the early history of these regions, which he outlines very well, and he certainly throws interesting light on the life and ideas of Samuel Butler. No one can be on safer ground in this section of his book. It is splendidly done.

The same comment does not apply, however, to other portions of the book. The honest and somewhat sensational record of his two unsuccessful attempts to scale Mount Tasman, which mountain he refers to as 'the most notoriously difficult New Zealand ice peak', reveals faulty judgement produced by a lack of knowledge of the conditions obtaining in the Hermitage region. His party left Syme's Ridge because it 'looked inclined to avalanche'. They chose the face of the mountain —surely at greater risk of disaster. If Syme's Ridge was in such bad condition, no attempt on Mount Tasman from the east could really be justified on that day, and certainly not a descent by the east face.

The attempt by the Silberhorn arête ended in a night out in a very treacherous place. Here again the ridge was forsaken, this time because of excessive steepness. The author is inclined to treat the spending of nights out in the Hermitage area with a levity which shows a lack of experience of the conditions which prevail there. This portion of his book would have been better treated without the authoritative note which is so justifiably adopted in the earlier portion—at any rate until several seasons of experience in the Hermitage region had been gained.

The book is slightly marred by the author's excessive fondness for quoting second-rate poetry, often without any particular point, and by the enormous number of strings of names of parties who have made first ascents. These disfigure many pages and should have been relegated to footnotes. And in parts his book is far too incoherent and disjointed, a fault which perhaps could have been rectified in a second edition.

Another grave defect—characteristic of too many books on travel and mountaineering—is the lack of adequate maps and sketches. These would have allowed the story to unfold itself much more simply to the reader. The author is not at fault here. This is a publisher's deficiency.—L. V. Bryant

New Zealand's Outlying Territory

CHATHAM EXILES. By F. A. Simpson. Wellington: A. H. and A. W. Reed, 1950, pp. 182.

Mr. Simpson has obviously had a most interesting time in preparing the material for this book. Anyone who wants to know something of the history of the Chatham Islands will find instruction given most readably in this little volume. Most New Zealanders know the Chathams as the tag end of the weather report and hitherto it has been difficult to find any connected account of the islands and the people who live there. Gratitude is due to those who manage the State Literary Fund for making this book possible.

The desperate days of the islands are past and the people now are peaceable, law-abiding and hardworking farmers and fishermen who would be welcome as citizens in any community. The reviewer, on his visits to the islands has been struck by their generous hospitality. Nevertheless the author's account of the Maori invasion of the Chathams, the massacre of the crew of the *Jean Bart*, and the capture of the *Rifleman* by the exiled Te Kooti and his henchmen to make possible his return to active rebellion in New Zealand, makes good reading, as does his long roll of wrecks on those dangerous shores. Incidentally many recognisable parts of these wrecks can be seen today incorporated in houses on the islands.

Mr. Simpson reminds his readers of the tragic loss in our time of the Moriori people and their culture because it was no-one's business to save them. We know all too little of the Moriori, and the author calls attention to the fact that none of the Moriori artifacts taken from the Chathams by whalers and others seem to have found their way to museums. Shand and Percy Smith saved some of the lore and traditions of the Moriori people but they arrived on the scene too late to record more than a fraction of the ethnologic material available a hundred years ago.

During a visit to the islands in 1940 to take part in centennial celebrations this reviewer was told that at least one family with predominantly Moriori blood was absent from the gathering on the day. The members considered the occasion to be the centennial of the European-aided invasion of the Chathams which overwhelmed their ancestors.

The roads mentioned by Mr. Simpson as being under construction are now completed, and the improved communications have already started a social revolution. Evening pictures for example are now possible. One feels that civilisation has arrived.

The Chatham Islands are legally part of New Zealand but are not of it. Islanders speak in their soft dialect of 'going up to New Zealand'. When they come here they will be met with a greater interest and understanding because of this book.

—T. H. McCombs

The Wayward Child

WORLD POLITICAL GEOGRAPHY. By G. Etzel Pearcy, Russel H. Fifield and associates. New York: Thomas Y. Crowell Company, 1948, pp. 653.

GEOGRAPHY BEHIND POLITICS. By A. E. Moodie. London: Hutchinson, n.d., pp. 178.

Of the various systematic studies which fall to the lot of the geographer none is more fertile of argument than political geography. Indeed it has even been claimed that political geography cannot be sustained as a systematic study with any degree of scientific accuracy since the material handled is restricted mainly to unique cases (R. Hartshorne: 'The Functional Approach in Political Geography', *Annals Assoc. Amer. Geogrs.*, Vol. 40, No. 2, 1950, p. 102). Hartshorne, more than any other geographer probably, has attempted to define the true nature of geographical studies —and thereby essayed to point to the limitations consequential upon his definitions. It is interesting, therefore, to note how far these two books fall within the true scope of political geography as defined by him.

Basically it may be argued that if geography is the science of areal differentiation, then political geography is concerned with the areal differentiation of political phenomena—phenomena which in large part constitute complexes known as states. There can be no 'geography behind politics'—simply because distinctiveness in political organisation characterises different regions known as states. The term must be reversed to possess true geographic significance. Otherwise it savours of determnism, or at best the study of relationships.

Hartshorne has concluded (*ibid.* p. 128) that a state, as a section of the earth's surface organised by man for a specific purpose, has genesis, structure and function, and that the study of the state as such may be approached through these. The genesis of states he rejects as being only historically significant and of academic interest merely to the geographer—comparable with the evolution of landforms. The tructural, or morphological, approach tends to be simply descriptive of the map, or, if taken to extremes, to border on the deterministic. The functional approach s left, and this is claimed to be the most reliable.

Moodie notes this functional aspect but relates both internal and external functions o environmental conditions. His chapter on the evolution of states deals not so much with the aspects condemned by Hartshorne as with the problems inherent in the increasing complexity of state development and organisation in these days of advanced technology and enlightenment. He attemps to distinguish between the people of a state and a nation, but not too satisfactorily, since at a later stage he talks of economic nationalism as appertaining to the state. With frontiers and boundaries Moodie is well acquainted and this aspect of the external functions of the state is competently handled. In short *Geography behind Politics,* despite its unfortunate title, is a book to be read by all geographers and to be praised or criticised according to the extent of their acceptance of the principle that human activity is influenced by environmental conditions.

World Political Geography, a book of a different calibre, comprises a series of broad regional studies of areas characterised by a common political organisation. Each unit is described in terms of its component elements—'the dynamic elements [of] people, ideas, and group motivations; the static elements [of] space, location, and material resources'. Occasionally this statement as to the content of political geography is lost sight of in a 'logical' treatment of historical development, physical features, people and resources. Little attempt is made to integrate the various studies by emphasising the distinctive totality of the political complexes, and it might be claimed, too, that the allocation of space is rather arbitrary. New Zealanders, for example, will quibble at the six pages allotted to Australia and New Zealand, as compared with the nine and a half for the Philippines; but this is to be expected in a textbook designed primarily for American students.

But the maps are disappointing; a good atlas would in most cases serve as well, if not better. Maps which show the distribution of political phenomena as distinctive elements appear but rarely.

Yet this book has much to commend it. Not since Bowman's *New World* first appeared in 1921 has there been any comparable attempt to present a complete story of the politico-geographic pattern of the world. Part I, on the nature and scope of political geography, presents a valuable introduction to the subject, although the reviewer would contest the claim that political geography and geopolitics are synonymous terms. The editors have had a difficult task to reconcile conflicting viewpoints, and it must be acknowledged that until the scope and content of political geography is clearly defined and accepted by all, such a book as this must have its critics. Sauer's 'wayward child of the geographical family' is rapidly growing up, but in the impetuosity of youth still exhibits something of his early upbringing.—JAMES W. FOX

A ONCE POPULAR TEXTBOOK

PHYSICAL GEOGRAPHY. By Philip Lake. Cambridge: Cambridge University Press, 1949, pp. 410. (Second edition, revised and enlarged.)

Lake's textbook when first published in 1915 marked a great step forward in that its style made it a book for students, not for school children. A great opportunity has been missed for adequate revision of this once popular text.

Any attempt to compress the content of physical geography into one small volume must do injustice to some part if not all of it. The atmosphere and ocean together are allotted 234 pages. This seems ample; the fact that seven of these pages are still devoted to deflection of moving bodies by the earth's rotation, the explanation of which is not intrinsically geographical, suggests that such an allowance is more than generous. The number of pages remaining for the land, or, as the geologically-minded editor calls it in the preface, the 'lithosphere', is 164, an allowance far from adequate. Many of these all too few pages are wasted, and the treatment is scrappy to say the least.

The atmosphere is treated in an interesting way, and probably the addition here of one more text to the host already on the market is justified, as the point of view is distinctly geographic and not that of the weather forecaster or mathematical physicist. The ocean is quite fully treated, and this part includes a reliable account of the phenomena and theories of tides and currents. A chapter on deposits on the ocean floor contains little of geographic interest, and the well-worn theories of atoll formation are threshed out again in another whole chapter.

It is concerning the treatment of the land that the reviewer is tempted to be critical. An analysis of this part chapter by chapter would occupy too much space, but a few brief comments seem called for. The well-written chapter on glaciation shows what can be done, even with a scanty allowance of pages, when thorough revision is attempted. It would be better appreciated by students if landscapes of kinds other than glacial had been equally well described for comparison. But even here, the emphasis on 'protection' is an archaism. Some of the old cuts could have been replaced advantageously by newer diagrams. It would have been better to rewrite also most of the remaining chapters, retaining perhaps only such introductory matter as 'materials of the earth's crust' and some passages in which Lake made original contributions to geomorphology.

Criticism of most of the chapters would be criticism of Lake's original writing and would be unfair thirty-five years after its publication; but it is fair criticism to comment unfavourably on the reprinting in the middle of the twentieth century of a truly Victorian treatment of rivers and development of river systems.

New matter is introduced into the chapter on shorelines, but the balance of treatment is upset by it. It is an account of spits and beach forms illustrated by interesting but rather lengthy descriptions of English examples—unfortunately almost the only specific examples of landforms described in the book. The very simple, but now old-fashioned, classification of coastal types as due to either subsidence or elevation of the land is retained; no mention is made here or elsewhere of the effects of glacial and postglacial changes of ocean level. The mistaken description of the Norwegian coast as a 'subsided highland region' is also retained.

As in the first edition, whole categories of features characteristic of the major relief of vast regions are left without explanation, description, or even brief mention— pediplanation, inselberg landscapes, fault scarps, block mountains and other forms of tectonic relief, consequent lines of main drainage in regions affected by active or recent earth movement, and the forms of relief in dissected structural plateaus and in valleys like that of the Colorado River. An isolated reference to the form of the Colorado canyon is entirely misleading.

Such omissions cannot be explained as due to lack of space, for a number of topics which are treated at some length might quite well have been passed over as of geologic rather than geographic importance. Earth movements, whether regional or differential, are, it is true, of first importance in geomorphology, but earth movements of the kind to which a chapter is devoted are only those responsible for development of geological structure, while earthquakes are treated only from the point of view of seismology.

The photographic illustrations, though not very numerous, are beautifully reproduced and are an example of results the Cambridge University Press can achieve by careful printing from fine-screen half-tone blocks on paper of excellent quality. Unfortunately there are only the scantiest references to the photographic illustrations in the text. Some of the line illustrations, but not enough, are new. Among these Figure 179 has a familiar look to the reviewer, but, as it is not acknowledged, the authors no doubt regard its design as original. Figure 118 has had the distribution of volcanoes added to it since it first appeared. New Zealand remains very aloof from any seismic region, but both islands are made to bristle with active volcanoes. In copying Figure 169, one of W. M. Davis's best block diagrams, though it seems strange to find one in such antipathetic company, the draughtsman has omitted the most essential features on which the whole design of the terrace pattern depends. These are outcrops of bedrock, parts of the crests of valley-side spurs, which have been buried and are reemerging.

This book is good in parts, but it cannot be recommended to students as a textbook; its treatment of geomorphology is much too fragmentary.—C. A. COTTON

A FRENCHMAN LOOKS AT EUROPE

A GEOGRAPHY OF EUROPE. By Jean Gottman. New York: Henry Holt and Company, 1950, pp. 688.

Jean Gottman, a French geographer who has spent considerable time outside his country, particularly in North America, and who has recently written a regional geography of both North and South America for general reading in France, has now produced the first major regional geography of Europe in English since the war. This time Gottman is writing primarily for American readers. The important changes emerging from the war have made a new survey of Europe desirable, but the task of describing and appraising the continent in the mid-twentieth century is a difficult one, as Gottman himself states in his preface. Less is probably known about Europe now, particularly its eastern half, than for several decades at least. Coupled with the problem of securing detailed, reliable, current information, Gottman has had to consider new developments emerging from the war, many of which continue in a state of flux.

The book is divided into six major parts, the first outlining some physical and cultural features of the continent as a whole, the last containing some general conclusions. The four intervening sections treat successively the author's four main divisions of the continent: Western, Central, Mediterranean and Eastern Europe. The recognition of a Central Europe in the divided continent of 1950 is defended with the thesis that Central Europe is a transitional area and a zone of instability between East and West. Gottman's division leaves Finland suspended as a completely detached, outlying segment of Central Europe. The individual chapters have the usual organisation in terms of countries or groups of countries. The chapter on Germany, a mere forty pages, seems too short for this country of continuing major importance, in spite of Gottman's plea that the fluidity of the current situation makes a more detailed discussion inadvisable.

Gottman reflects the French tradition of geography. Varying cultural attributes of diverse peoples bulk large in the origin of regional differences. A distinctive way of living, a particular code of beliefs, may be the basis of regional character. To Gottman's objective appraisals of physical and economic facts are added subjective impressions of regional spirit or atmosphere. In the narrow streets of Copenhagen 'one feels the tradition of old culture and the open-mindedness and eagerness of a people who always have sailed broad seas and mingled with foreigners', while the ranges ribbing the Iberian Meseta are 'permeated with austerity and even despair'. Such impressions can make valuable and interesting reading, but only when the background of the writer is kept in mind. A Spanish geographer's feeling for the Meseta might well be expressed in quite a different way.

The effectiveness of *A Geography of Europe* is seriously impaired, however, by frequent Gallicisms, awkward and ungrammatical sentences, inconsistencies of spelling for certain place names, and general evidence of poor and hasty editing. The English is often an impoverished one: 'scalloped' and 'sculpted' appear with monotonous regularity. The book contains more than its fair share of 'east' being written for 'west' and vice versa. Part of the description of Rumania is rendered worthless on this count.

The author has depended extensively on reproductions of maps appearing in other publications, particularly the *Geographical Review*. The result in this case is rather unsatisfactory; cartographic illustration becomes fortuitous, and relatively minor points are often illustrated by maps, whereas other, more important sections of the text may remain unillustrated. The most serious fault, however, is the age of many of the maps. A geographer of Gottman's standing should have eschewed distribution maps which are patently out-of-date. The photographic side of the book, by contrast, is excellent. Photos are numerous, clearly reproduced, and usually aptly chosen.

A few factual errors are scattered through the book; the statement that Mt. Olympus rises from the midst of the island of Euboea is typical. The author inclines to some sweeping statements: 'The economic history of all the western half of Europe could be written in terms of the great fairs of Lyon, Burgundy, Champagne, Paris, Flanders, and the Rhine valley'. Moral judgments have occasionally filtered into the text, particularly in the sections on Germany, Italy and the Soviet Union. Yet the book remains an interestingly written and much needed contribution to the current literature on Europe.—Donald J. Patton

The World of Maps

MODERN CARTOGRAPHY: BASE MAPS FOR WORLD NEEDS. New York: United Nations Department of Social Affairs, 1949, pp. 95.

This booklet contains the report of a Committee of Experts on Cartography which met at Lake Success in March and April 1949 to consider the mapping needs of the world. An immense amount of information has been packed into the ninety-five pages of the booklet, which should be in the hands of everyone with an interest in maps.

A preliminary section stresses the urgent need for modern topographic maps, shows how little has yet been done, and advances a few reasons for the present inadequate coverage of the world. To remedy this unsatisfactory situation, the committee recommended that the United Nations initiate regional meetings for the discussion of cartographic matters, to be attended by representatives of governments having common interests in particular areas; that there be set up in the Secretariat of the United Nations a cartographic office for the provision of maps and for assistance and advice in cartographic activities; that there be listed a panel of consultants on whom the cartographic office might call for service or advice; and that annual meetings, attended by representatives of the regional meetings and of international scientific and technical organisations, should be called for reviewing the progress and problems of world mapping. All of these recommendations are discussed in detail.

The second part of the booklet is a study of modern cartographic methods, including such recent developments as flare triangulation and electronic methods of distance measurement. Cartography is broadly defined as the science of preparing all types of maps and charts, including every operation from original surveys to final printing of copies. A short bibliography is added to each section of this study. (It is odd, however, to find Pizetti's *Trattato di Geodesia Teoretica* cited under a German title.)

A criticism which a New Zealand reviewer could make of the information contained in the report is of the treatment which New Zealand receives in the world map showing the status of geodetic control surveys—a complete blank. In fact, the whole of the North Island and the eastern half of the South Island are now covered by a first-order geodetic control network, and considerable areas of both islands are covered by second-order networks coming within Class A of the report. These surveys have been executed to the specifications adopted by the International Union of Geodesy and Geophysics, of which New Zealand has been a member since 1927, and a report on geodetic surveys presented to the Congress of the Union at Oslo in 1948 should have been available to the compilers of this booklet.—L. P. LEE

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The aims of the Society as stated in the constitution are 'to promote and stimulate the study of geography'. These are the aims of more than one Society in the world and the New Zealand Geographical Society is particularly concerned with geography in New Zealand. It is therefore the Society's policy to stimulate geographic studies of New Zealand and matters closely related to the Dominion.

The Society undertakes the publication of a journal, the *New Zealand Geographer*, and of a *Record* of its proceedings, both of which at present appear twice a year. Branches of the Society organise lectures, study groups, and excursions, and encourage their members to prepare matter for publication in the *New Zealand Geographer*. Contributions from overseas writers and those who are not members of the Society are also encouraged.

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